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APPROXIMATE CALCULATION OF TURBULENT BOUNDARY-LAYER DEVELOPMENT IN COMPRESSIBLE FLOW

By Maurice Tucker

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Cleveland, Ohio

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Page 2, line 12: Reference 2 should be reference 1.

Page 4, the line following the unnumbered equation should read as follows: "is independent of any additional Mach number dependence according to the reference-temperature"

Page 7, line 4:

$$C_f\left(\frac{u_1 x}{1}\right)^{1/7} \quad \text{should be} \quad C_f\left(\frac{u_1 x}{\nu_1}\right)^{1/7}$$

Page 7, line 3 from the bottom: N_1 should be N.

Page 8: The line preceding equation (10a) should be deleted.

Page 9: Equation (10b), the preceding line, and the following definition of $\underline{J}$ should be deleted.

Page 10: The following note should be added to the definition of r_1:

$$(r_{1,a} = 0)$$

Pages 11 and 12, equations (12b), (13b), and (13c): The quantities $(r_b - r_0)$ and $(r_a - r_0)$ should be $(r_{1,b} - r_0)$ and $(r_{1,a} - r_0)$, respectively.

Page 12, equations (13a) and (13c): Replace $\underline{F}_{M_b}$ by $\underline{E}_{M_b}$, $\underline{E}_{M_a}$ by $\underline{F}_{M_a}$, $\underline{J}_{M_b}$ by $\underline{I}_{M_b}$, and $\underline{J}_{M_a}$ by $\underline{I}_{M_a}$.

Page 12: Equation (14) should read

$$\frac{r_0}{r_0 - r_{1,b}} \quad \text{or} \quad \frac{r_b}{r_a} = \frac{M_a}{M_b}\left(\frac{5+M_b{}^2}{5+M_a{}^2}\right)^3$$

Page 12: The line following equation (13d) should read "Planar divergent or convergent flow fields may be regarded as radial flows for"

Page 13: Line 1 should read "Inasmuch as the length $r_b - r_a$ or $r_0 - r_{1,b}$ is known, the radii r_a and r_b"

Page 15: The following note should be added to the definition of r_1:

$$(r_{1,a} = 0)$$

Page 21, Table II, column 7: The value 109.11741 should be 169.11741.

Pages 27, 28, and 29: Table IV should be deleted.

NACA - Langley Field, Va.

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SUMMARY

Numerical solutions of quantities appearing in the Kármán momentum equation for the development of a turbulent boundary layer in plane and in radial compressible flows along thermally insulated surfaces are presented in tabular form for a range of Mach numbers from 0.100 to 10. Through use of these tables, approximate calculation of boundary-layer growth is reduced to routine arithmetic computation. The variation of local skin-friction coefficient with Mach number is obtained through the assumption that the Falkner relation for low-speed flat-plate friction coefficients is dependent only on Reynolds number provided that the fluid properties are evaluated at the arithmetic mean of the wall temperature and the stream temperature. The friction Mach number relation thus obtained closely follows the trend of the extended Frankl-Voishel analysis.

INTRODUCTION

Use of the Kármán momentum equation for computation of supersonic turbulent boundary-layer development essentially requires a knowledge of the effect of Mach number and pressure gradient upon the local skin-friction coefficient. The tabulations of reference 1 for obtaining the boundary-layer development along thermally insulated surfaces were based on two extreme assumptions as to the Mach number effect. The assumptions may be described as follows. Falkner's empirical low-speed relation for the local turbulent skin-friction coefficient of a flat plate (reference 2) can be written

$$\frac{\tau}{\rho u_1^{\,2}} = \frac{0.0131}{R^{1/7}}$$

where

τ local skin-friction stress

ρ density

u_1 velocity at outer edge of boundary layer

R Reynolds number based on distance from start of boundary-layer development

The nondimensional ratio $\tau/\rho u_1^2$ is taken to be dependent only on Reynolds number provided that the density and the kinematic viscosity are evaluated at some reference temperature in the boundary layer. The static-pressure gradient normal to the wall or bounding surface is taken as zero for the boundary-layer region. The two assumptions of reference 2 are obtained by selecting as a reference temperature the stream temperature and the wall temperature, respectively. With stream temperature as the reference, the local skin-friction coefficient $\tau/\rho_1 u_1^2$ (where ρ_1 is the density at the outer edge of the boundary layer) becomes independent of Mach number. An extreme variation of $\tau/\rho_1 u_1^2$ with Mach number that is almost identical with the variation suggested by von Kármán in reference 3 is obtained by evaluating the fluid properties at the wall temperature.

The Frankl-Voishel analysis of reference 4, based on von Kármán's formulation of the mixing length, predicts a variation of local skin-friction coefficient with Mach number for zero pressure-gradient flow that is less severe than the variation obtained by use of wall temperature as a reference. The final results of reference 4 are limited to the subsonic Mach numbers because of the series expansions used to integrate in quadrature. This limitation is avoided in reference 5 by use of numerical integration to obtain, for constant free-stream Reynolds number of 7×10^6, the reduction of mean friction-drag coefficient with Mach number shown in figure 1.

Experimental data on turbulent friction-drag coefficients in supersonic flow under action of zero pressure gradient are not yet adequate to establish the effect of Mach number upon friction drag. The variation of flat-plate mean friction-drag coefficient with Mach number given by the extended Frankl-Voishel analysis appears compatible with the experimental trends given in reference 5.

As shown herein, selection of the arithmetic mean of the wall temperature and the stream temperature as a reference temperature

leads to a friction-drag Mach number relation that is both in substantial agreement with the extended Frankl-Voishel relation and amenable to boundary-layer calculation. This report presents the tabulations required for approximate computation of compressible turbulent-boundary-layer development based on selection of the arithmetic-mean temperature as the reference temperature. These tabulations were made at the NACA Lewis laboratory.

ANALYSIS

Physical Assumptions

The following analysis is essentially that of reference 1 with the modifications required to incorporate the new assumption regarding the local skin-friction coefficient. The wall or bounding surfaces are considered to be thermally insulated and the effective Prandtl number is taken as unity. The stream stagnation temperature and the wall temperature are thus equal. The energy equation

$$c_p t + \frac{u^2}{2} = \text{constant}$$

is then assumed to be applicable to turbulent boundary-layer flow. The ratio of specific heats γ is taken as 1.40, independent of temperature. (All symbols are defined in the appendix.)

From the assumptions of constant static pressure and constant stagnation temperature along any section normal to the wall in the boundary layer and through use of the perfect gas law, the boundary-layer density ratio is given as

$$\frac{\rho}{\rho_1} = \frac{1}{m^2\left[\frac{1+m^2}{m^2} - \left(\frac{u}{u_1}\right)^2\right]} \tag{1}$$

With the use of the definition for arithmetic-mean temperature $t_{am} \equiv \frac{1}{2}(T_w+t_1)$, the density ratio ρ_{am}/ρ_1 is obtained from equation (1) as

$$\frac{\rho_{am}}{\rho_1} = \frac{2}{2+m^2} \tag{1a}$$

The local skin-friction coefficient is

$$\frac{\tau}{\rho_1 u_1{}^2} = \frac{\tau}{\rho_{am} u_1{}^2} \frac{\rho_{am}}{\rho_1} = 0.0131 \left(\frac{\nu_{am}}{u_1 x}\right)^{1/7} \frac{\rho_{am}}{\rho_1} \tag{2}$$

Inasmuch as the quantity

$$\frac{\tau}{\rho_{am} u_1{}^2} = 0.0131 \left(\frac{\nu_{am}}{u_1 x}\right)^{1/7} \equiv \frac{0.0131}{R_{am}{}^{1/7}}$$

is independent of Mach number according to the reference-temperature hypothesis, the variation of the local skin-friction coefficient with Mach number arises from the dependence of the density ratio ρ_{am}/ρ_1 on Mach number shown in equation (1a). Use of equation (2) implies that the effect of pressure gradient upon skin friction is of secondary importance. This implication is reasonably valid for favorable pressure gradients and possibly even for very moderate adverse gradients.

The mean velocity profile for a compressible turbulent boundary layer is approximated by the power-law velocity profile

$$\frac{u}{u_1} = \left(\frac{y}{\delta}\right)^{1/N} \tag{3}$$

For a constant stagnation-temperature profile, the arithmetic-mean temperature occurs at the point in the boundary layer where $\left(\frac{u}{u_1}\right)^2 = \frac{1}{2}$ or, for a power-law profile, at $\frac{y}{\delta} = \left(\frac{1}{2}\right)^{N/2}$.

An approximate guide for the variation of the velocity-profile parameter N with Reynolds number may be obtained from the rearrangement of von Kármán's logarithmic velocity-profile relation for low-speed turbulent flow given in reference 6.

$$e^{\left(\frac{u}{u_1} - 1\right)} = \left(\frac{y}{\delta}\right)^{\frac{1}{k}\sqrt{c_f}} \tag{4}$$

where the quantity c_f is defined as $\tau/\rho u_1{}^2$. For low-speed flows the density is practically constant through the boundary layer. On the

assumption that the velocity profile is independent of Mach number, the quantity c_f is taken as $\tau/\rho_{am}u_1^2$ for this analysis. The following relation may be obtained from equations (2) to (4)

$$N = \frac{k}{\sqrt{0.0131}} R_{am}^{1/14}\left(\frac{\frac{u}{u_1} - 1}{\log_e \frac{u}{u_1}}\right)$$

Evaluating the velocity ratio arbitrarily at the point where the arithmetic-mean temperature is obtained and taking $k=0.3$ (reference 1) give the relation

$$N = 2.2 R_{am}^{1/14} \tag{5}$$

The qualitative nature of this relation should be noted. Table XI of reference 1 indicates that for favorable pressure gradients the important boundary-layer quantities θ and δ^* are not greatly influenced by the value of N selected. Lack of sufficient data even at low speeds precludes consideration of the effect of adverse pressure gradients upon either mean-velocity profiles or local skin-friction coefficients.

Treatment of Momentum Equation

By analogy with the equations derived in reference 1, the momentum equation

$$\tau = \frac{d}{dx}(\rho_1 u_1^2\theta) + \rho_1 u_1 \delta^* \frac{du_1}{dx}$$

can be put in the form

$$\frac{d\delta}{dx} + \varphi \frac{dM_1}{dx} \delta = \frac{\rho_{am}}{\rho_1} \frac{\tau}{f\rho_{am}u_1^2} = \frac{K\psi_{am}}{x^{1/7}} \tag{6}$$

where

$$\varphi \equiv \frac{g+f(2-7m^2) + \dfrac{2m^2N}{(1+m^2)^2}\displaystyle\int_0^1 \frac{s^2(s^N-s^{N+1})ds}{\left(1-\dfrac{m^2s^2}{1+m^2}\right)^2}}{\sqrt{5}\ fm\ (1+m^2)}$$

$$K \equiv 0.0131\left(\frac{\mu_0}{\rho_0 a_0}\right)^{1/7}$$

$$\psi_{am} \equiv \frac{(1+m^2)^{2/7}}{\left(1+\dfrac{m^2}{2}\right)^{5/7} fM_1^{\ 1/7}}$$

With zero pressure gradient $\left(\dfrac{dM_1}{dx} = 0\right)$, equation (6) simplifies to

$$\frac{d\delta}{dx} = \frac{K\psi_{am}}{x^{1/7}}$$

which for constant N and thus constant f has the solution

$$f\delta_b \equiv \theta_b = \frac{7K}{6}\left[\frac{(1+m^2)^2}{M_1\left(1+\dfrac{m^2}{2}\right)^5}\right]^{1/7}\left(x_b^{\ 6/7}-x_a^{\ 6/7}\right) + \theta_a \qquad (7)$$

The subscripts a and b designate the start and end, respectively, of the integration interval.

The effect of the reference-temperature assumption upon the Mach number variation of the flat-plate mean friction-drag coefficient can now be obtained. The mean friction-drag coefficient C_f is defined as the friction drag per unit wetted area divided by free-stream dynamic pressure. For flat-plate flow, the mean friction-drag coefficient may be expressed in terms of θ_b as

$$C_f = \frac{2\theta_b}{x_b} \tag{8}$$

where $\theta_a = 0$.

If the temperature-viscosity relation is assumed to be $\mu_0 = \mu_1\left(\frac{T_0}{t_1}\right)$, the friction-drag parameter $C_f\left(\frac{u_1 x}{1}\right)^{1/7} \equiv C_f\, R_1{}^{1/7}$ for the arithmetic-mean temperature as reference temperature is obtained from equations (7) and (8) as

$$(C_f)_{am}\, R_1{}^{1/7} = \frac{0.0306}{\left(1 + \frac{m^2}{2}\right)^{5/7}} \tag{9a}$$

For the wall temperature as reference temperature, equation (8) and equation (13b) of reference 1, which corresponds to equation (7), are used to obtain

$$(C_f)_w\, R_1{}^{1/7} = \frac{0.0306}{(1+m^2)^{5/7}} \tag{9b}$$

The ratio of compressible-flow to incompressible-flow flat-plate mean friction-drag coefficient is shown in figure 1 for the two reference-temperature assumptions. The variation of mean friction-drag coefficient predicted by the arithmetic-mean temperature as reference agrees very well with the modified Frankl-Voishel variation.

With the assumption, as in reference 1, that N_1, $\frac{dx}{dM_1}$, and $x^{1/7}$ are constant for a given integration interval, the solution of equation (6) may be put in the form

$$\delta_{M_b} = e^{-\int_1^{M_b} \varphi dM_1} \frac{K \frac{dx}{dM_1}}{\bar{x}^{1/7}} \left(\int_1^{M_b} \psi_{am} e^{\int_1^{M_1} \varphi dM_1} dM_1 - \int_1^{M_a} \psi_{am} e^{\int_1^{M_1} \varphi dM_1} dM_1 \right) +$$

$$\delta_{M_a} e^{\int_1^{M_a} \varphi dM_1} e^{-\int_1^{M_b} \varphi dM_1} \tag{10}$$

where M_a and M_b denote the stream Mach numbers at the start and end, respectively, of the integration interval and $\bar{x}$ denotes the mean distance of the interval from the effective starting point of boundary-layer development. In order to determine $\bar{x}$, the assumption is made that θ_{M_a} develops under action of a zero pressure gradient at the Mach number M_a and equation (7) is used. With subsonic flow, the Mach number for the lower limit of integration in equation (10) is arbitrarily chosen as 0.100.

The following variations of equation (10) will be found convenient for computation of two-dimensional flows:

For favorable pressure gradients (dM_1/dx positive):

$$\delta_{M_b} = \underline{E}_{M_b} \frac{K \frac{dx}{dM_1}}{\bar{x}^{1/7}} \left(\underline{I}_{M_b} - \underline{I}_{M_a} \right) + \delta_{M_a} \underline{E}_{M_b} \underline{F}_{M_a} \tag{10a}$$

where

$$\underline{E} \equiv e^{-\int_1^M \varphi dM_1} \quad \text{(from table I)}$$

$$\underline{F} \equiv e^{\int_1^M \varphi dM_1} \quad \text{(from table II)}$$

$$\underline{I} \equiv \int_1^M \psi_{am}\, e^{\int_1^{M_1} \varphi dM_1}\, dM_1 \quad \text{(from table III)}$$

For adverse pressure gradients (dM_1/dx negative):

$$\delta_{M_b} = \underline{F}_{M_b} \frac{K \dfrac{dx}{dM_1}}{\overline{x}^{1/7}} \left(\underline{J}_{M_b} - \underline{J}_{M_a}\right) + \delta_{M_a}\, \underline{E}_{M_a}\, \underline{F}_{M_b} \tag{10b}$$

where

$$\underline{J} \equiv \int_1^M \psi_{am}\, e^{-\int_1^{M_1} \varphi dM_1}\, dM_1 \quad \text{(from table IV)}$$

Tables I, II, and V to VII are taken from reference 1.

For diverging radial flows the momentum equation can be written

$$\frac{d\delta}{dr} + \left(\varphi\, \frac{dM_1}{dr} + \frac{1}{r}\right)\, \delta = \frac{K\psi_{am}}{x^{1/7}} \tag{11a}$$

where r designates the distance from the apparent origin of the radial flow to the point in question. The following variation of equation (11a) is convenient for converging radial flow:

$$\frac{d\delta}{dr_1} + \left(\varphi \frac{dM_1}{dr_1} + \frac{1}{r_1 - r_0}\right) \delta = \frac{K\psi_{am}}{x^{1/7}} \tag{11b}$$

where

r_1 distance from start of integration interval to point in equation

r_0 distance from start of integration interval to apparent sink in converging radial potential flow

Equations (11) involve the assumption that the local skin-friction coefficient in radial flow is identical with that for two-dimensional flow.

With the approximations used for equation (10), the respective solutions of equations (11a) and (11b) are

$$\delta_{M_b} = e^{-\int_1^{M_b} \varphi dM_1} \frac{K \frac{dr}{dM_1} \bar{r}}{r_b \bar{x}^{1/7}} \left(\int_1^{M_b} \psi_{am} e^{\int_1^{M_1} \varphi dM_1} dM_1 - \int_1^{M_a} \psi_{am} e^{\int_1^{M_1} \varphi dM_1} dM_1 \right) +$$

$$\delta_{M_a} \frac{r_a}{r_b} e^{\int_1^{M_a} \varphi dM_1} e^{-\int_1^{M_b} \varphi dM_1} \tag{12a}$$

and

$$\delta_{M_b} = e^{-\int_1^{M_b} \varphi dM_1} \left[\frac{K \frac{dr_1}{dM_1} \left(\overline{r_1 - r_0}\right)}{(r_b - r_0)\ \bar{x}^{1/7}}\right] \left(\int_1^{M_b} \psi_{am}\, e^{\int_1^{M_1} \varphi dM_1} dM_1 - \int_1^{M_a} \psi_{am}\, e^{\int_1^{M_1} \varphi dM_1} dM_1\right) +$$

$$\delta_{M_a} \frac{(r_a - r_0)}{(r_b - r_0)} e^{\int_1^{M_a} \varphi dM_1}\, e^{-\int_1^{M_b} \varphi dM_1} \qquad (12b)$$

where

$\bar{r}$ mean distance of interval designated by M_a and M_b from apparent source in diverging radial potential flow

$\left(\overline{r_1 - r_0}\right)$ mean distance of interval designated by M_a and M_b to apparent sink in converging radial potential flow

In application of equation (12), the assumption is again made that θ_{M_a} develops under the action of a zero pressure gradient at the Mach number M_a. With subsonic flow, the Mach number for the lower limit of integration is arbitrarily chosen as 0.100.

The following variations of equations (12) are convenient for computation of radial flows:

Subsonic flow under adverse pressure gradient $(dM_1/dr$ negative):

$$\delta_{M_b} = E_{M_b} \frac{K \frac{dr}{dM_1} \bar{r}}{r_b \bar{x}^{1/7}} \left(J_{M_b} - J_{M_a}\right) + \delta_{M_a} \frac{r_a}{r_b} E_{M_a} F_{M_b} \tag{13a}$$

Subsonic flow under favorable pressure gradient (dM_1/dr positive):

$$\delta_{M_b} = E_{M_b} \frac{K \frac{dr_1}{dM_1} (\overline{r_1 - r_0})}{(r_b - r_0)\ \bar{x}^{1/7}} \left(I_{M_b} - I_{M_a}\right) + \delta_{M_a} \frac{(r_a - r_0)}{(r_b - r_0)} E_{M_b} F_{M_a} \tag{13b}$$

Supersonic flow under adverse pressure gradient (dM_1/dr negative):

$$\delta_{M_b} = F_{M_b} \frac{K \frac{dr_1}{dM_1} (\overline{r_1 - r_0})}{(r_b - r_0)\ \bar{x}^{1/7}} \left(J_{M_b} - J_{M_a}\right) + \delta_{M_a} \frac{(r_a - r_0)}{(r_b - r_0)} E_{M_a} F_{M_b} \tag{13c}$$

Supersonic flow under favorable pressure gradient (dM_1/dr positive):

$$\delta_{M_b} = E_{M_b} \frac{K \frac{dr}{dM_1} \bar{r}}{r_b\ \bar{x}^{1/7}} \left(I_{M_b} - I_{M_a}\right) + \delta_{M_a} \frac{r_a}{r_b} E_{M_b} F_{M_a} \tag{13d}$$

Divergent or convergent flow fields may be regarded as radial flows for which the position of the apparent source or sink is variable. For the boundary-layer calculations, this continuous variation may be approximated as a stepwise variation. From the one-dimensional area-ratio relation, which is applicable to radial flows, the following equation results:

$$\frac{r_b}{r_a} = \frac{M_a}{M_b}\left(\frac{5+M_b^2}{5+M_a^2}\right)^3 \tag{14}$$

Inasmuch as the length $r_b - r_a$ is known, the radii r_a and r_b are determined from the known Mach number distribution along the selected streamline.

The approximate turbulent boundary-layer development in plane and radial flows along thermally insulated surfaces can be obtained from the preceding equations. For two-dimensional flow, equations (10a) and (10b) are used for favorable and adverse pressure gradients, respectively, to obtain the variation of the boundary-layer thickness δ along the surface under consideration. Equations (13) are used to obtain corresponding results for radial flow. The various quantities needed to evaluate δ, δ^*, and θ from these equations are listed in tables I to IV and VII. Equation (7) is applicable to the case of zero pressure gradient. With the variation of the boundary-layer thickness δ for a given streamwise integration interval thus known, the local values of momentum thickness θ and of displacement thickness δ^* are calculated from the ratios f and g of tables V and VI, respectively. The free-stream Mach number distribution is known and appropriate values of the parameter N can be obtained from equation (5). Linear interpolation for M and N is within the accuracy of the various approximations. The constant $K \equiv 0.0131\left(\frac{\mu_0}{\rho_0 a_0}\right)^{1/7}$ has the dimension of length and any consistent system of units may be used. In engineering units the constant is written

$$K = 0.0218\left(\frac{\mu_0\sqrt{T_0}}{p_0}\right)^{1/7} \tag{15}$$

where the coefficients of viscosity, temperature, and pressure are assigned the following units, respectively: pound-seconds per square foot, degrees Rankine, and pounds per square foot. All distances are then to be expressed in feet and the boundary-layer quantities δ, δ^*, and θ obtained will be given in feet.

Comparison of Analysis and Experiment

In reference 1 a comparison is made of the calculated and measured boundary-layer growth in a Mach number 2.08 supersonic tunnel with a contour-plate width of 3.84 inches and test-section dimensions of 3.84 by 10 inches. In figure 2 of this report the calculated boundary-layer growths obtained through use of the stream, wall, and arithmetic-mean temperatures as reference temperatures are compared with the growth measured along the center line of the contour plate. In view of the

secondary flows discussed in reference 7 no comparison has been made for the side-plate development. The comparison of figure 2 favors use of the arithmetic-mean temperature as a reference. Further experimental studies are required for a decisive comparison.

CONCLUDING REMARKS

In the absence of adequate fundamental knowledge concerning turbulent shear flows, prediction of turbulent boundary-layer growth must depend on use of the integrated equations of motion and certain assumptions regarding the mean-velocity profiles and the local skin-friction coefficient. The principal assumption for compressible flow concerns the variation of local skin-friction coefficient with Mach number. The variation predicted by the Frankl-Voishel analysis as extended for high-speed flow appears compatible with the limited experimental data available for supersonic flow.

The present method uses a friction Mach number relation that almost duplicates the extended Frankl-Voishel variation and is simple enough in form to be used for boundary-layer calculation. With the tabulations presented herein, the approximate development of a turbulent boundary layer in plane and in quasi-radial compressible potential flow along thermally insulated surfaces under action of favorable pressure gradients may be obtained through routine arithmetic computation. Inasmuch as the effects of pressure gradient upon the mean-velocity profile and upon the local skin-friction coefficient are not considered and inasmuch as reliable separation criteria have not yet been established, application of the analysis to flows under action of substantial adverse pressure gradients is open to question. It may also be noted that the tabulations were extended to a Mach number of 10 primarily as a means of obtaining at least a first approximation to the boundary-layer development. Decisive experimental verification of the predictions of the present analysis is required.

Lewis Flight Propulsion Laboratory,
National Advisory Committee for Aeronautics,
Cleveland, Ohio, December 13, 1950.

APPENDIX - SYMBOLS

The following symbols are used in this report:

a	speed of sound
C_f	mean friction-drag coefficient, friction drag per unit wetted area divided by free-stream dynamic pressure
c_f	local skin-friction coefficient used in logarithmic profile relation, equation (4)
c_p	specific heat at constant pressure
f	ratio of momentum thickness to boundary-layer thickness, θ/δ
g	ratio of displacement thickness to boundary-layer thickness, δ^*/δ
K	constant based on stagnation conditions (See equations (6) and (15).)
k	constant
M	Mach number
m^2	Mach number parameter, $m^2 \equiv \frac{\gamma-1}{2} {M_1}^2 = \frac{{M_1}^2}{5}$
N	velocity-profile parameter, $\frac{u}{u_1} = \left(\frac{y}{\delta}\right)^{1/N}$
P	stagnation pressure
R	Reynolds number based on distance from effective start of boundary-layer development
r	radial distance of line of constant Mach number from apparent source in diverging radial potential flow
r_o	radial distance from start of integration to apparent sink in converging radial flow
r_1	radial distance of line of constant Mach number from start of integration to point in question for converging radial potential flow
$\bar{r}$	mean distance of interval designated by M_a and M_b from apparent source in diverging radial potential flow

$\overline{r_1 - r_0}$ mean distance of interval designated by M_a and M_b to apparent source in converging radial potential flow

s variable of integration

T stagnation temperature

t static temperature

u velocity

x distance along surface measured from effective start of boundary-layer development

$\bar{x}$ mean distance of surface interval from effective start of boundary-layer development

y normal distance from surface

γ ratio of specific heats

δ nominal boundary-layer thickness, distance from wall to point in boundary layer where velocity is approximately equal to local stream velocity

δ^* boundary-layer displacement thickness, $\dfrac{1}{\rho_1 u_1}\displaystyle\int_0^\delta (\rho_1 u_1 - \rho u)dy$

θ boundary-layer momentum thickness, $\dfrac{1}{\rho_1 u_1^2}\displaystyle\int_0^\delta \rho u(u_1 - u)dy$

μ coefficient of viscosity

ν kinematic viscosity, μ/ρ

ρ density

τ local skin-friction stress

φ coefficient defined in equation (6)

ψ_{am} friction parameter, $\dfrac{(1 + m^2)^{2/7}}{\left(1 + \frac{m^2}{2}\right)^{5/7} f M_1^{1/7}}$

Subscripts:

0 stagnation

1 local stream

a start of integration interval

b end of integration interval

w wall

am arithmetic mean

REFERENCES

1. Tucker, Maurice: Approximate Turbulent Boundary-Layer Development in Plane Compressible Flow along Thermally Insulated Surfaces with Application to Supersonic-Tunnel Contour Correction. NACA TN 2045, 1950.

2. Falkner, V. M.: A New Law for Calculating Drag. Aircraft Eng., vol. XV, no. 169, March 1943, pp. 65-69.

3. de Kármán, Th.: The Problem of Resistance in Compressible Fluids. Quinto Convegno "Volta", Reale Accademia d' Italia (Roma), Sett. 30 - Ott. 6, 1935, pp. 3-57.

4. Frankl, F., and Voishel, V.: Turbulent Friction in the Boundary Layer of a Flat Plate in a Two-Dimensional Compressible Flow at High Speeds. NACA TM 1053, 1943.

5. Rubesin, Morris W., Maydew, Randall C., and Varga, Steven A.: An Analytical and Experimental Investigation of the Skin Friction of the Turbulent Boundary Layer on a Flat Plate at Supersonic Speeds. NACA TN 2305, 1951.

6. Dryden, Hugh L.: Air Flow in the Boundary Layer near a Plate. NACA Rep. 562, 1936.

7. Brinich, Paul F.: Boundary-Layer Measurements in 3.84- by 10-Inch Supersonic Channel. NACA TN 2203, 1950.

TABLE I - VARIATION OF $\underline{E}$ WITH MACH NUMBER
M AND VELOCITY-PROFILE PARAMETER N

$$\left[\underline{E} = e^{-\int_{0.100}^{M} \varphi dM_1}\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	1.0000000	1.0000000	1.0000000	1.0000000
.200	.0966699	.1045974	.1092891	.1124112
.300	.0251985	.0285359	.0305797	.0319672
.400	.0099328	.0116115	.0126636	.0133874
.500	.0049379	.0059131	.0065348	.0069667
.600	.0028542	.0034839	.0038905	.0041751
.700	.0018362	.0022766	.0025639	.0027661
.800	.0012804	.0016083	.0018239	.0019762
.900	.0009432	.0012079	.0013777	.0014981
1.000	.0007312	.0009530	.0010924	.0011913

TABLE I - VARIATION OF $\underline{E}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[E = e^{-\int_1^M \varphi dM_1}\right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	1.00000	1.00000	1.00000	1.00000	3.40	0.58555	0.61904	0.63006	0.63254
1.04	.91732	.92040	.92197	.92291	3.44	.59750	.63170	.64281	.64516
1.08	.84675	.85227	.85509	.85677	3.48	.60984	.64475	.65595	.65816
1.12	.78618	.79365	.79747	.79973	3.52	.62256	.65821	.66949	.67157
1.16	.73392	.74297	.74758	.75030	3.56	.63567	.67208	.68344	.68537
1.20	.68864	.69897	.70422	.70730	3.60	.64918	.68636	.69781	.69958
1.24	.64925	.66063	.66639	.66976	3.64	.66309	.70106	.71259	.71420
1.28	.61486	.62710	.63329	.63689	3.68	.67740	.71619	.72780	.72924
1.32	.58476	.59772	.60425	.60803	3.72	.69213	.73175	.74345	.74470
1.36	.55835	.57191	.57871	.58265	3.76	.70727	.74776	.75953	.76060
1.40	.53512	.54920	.55624	.56028	3.80	.72285	.76421	.77606	.77693
1.44	.51467	.52919	.53642	.54056	3.84	.73886	.78111	.79304	.79370
1.48	.49666	.51157	.51896	.52317	3.88	.75530	.79848	.81048	.81093
1.52	.48078	.49603	.50356	.50783	3.92	.77220	.81631	.82838	.82861
1.56	.46680	.48236	.49001	.49431	3.96	.78954	.83462	.84676	.84676
1.60	.45450	.47034	.47809	.48243	4.00	.80735	.85342	.86563	.86538
1.64	.44370	.45980	.46764	.47200	4.04	.82563	.87271	.88498	.88448
1.68	.43424	.45060	.45852	.46289	4.08	.84439	.89250	.90484	.90407
1.72	.42601	.44260	.45059	.45497	4.12	.86364	.91280	.92520	.92415
1.76	.41887	.43569	.44375	.44814	4.16	.88337	.93362	.94607	.94474
1.80	.41273	.42978	.43790	.44229	4.20	.90361	.95496	.96747	.96583
1.84	.40751	.42479	.43297	.43736	4.24	.92436	.97684	.98940	.98745
1.88	.40313	.42063	.42887	.43325	4.28	.94563	.99927	1.01188	1.00960
1.92	.39953	.41726	.42555	.42993	4.32	.96743	1.02224	1.03490	1.03229
1.96	.39664	.41460	.42295	.42731	4.36	.98976	1.04579	1.05849	1.05552
2.00	.39442	.41262	.42102	.42537	4.40	1.01264	1.06990	1.08264	1.07931
2.04	.39282	.41126	.41972	.42406	4.44	1.03607	1.09460	1.10737	1.10367
2.08	.39180	.41050	.41901	.42334	4.48	1.06007	1.11989	1.13270	1.12859
2.12	.39134	.41029	.41887	.42317	4.52	1.08465	1.14579	1.15862	1.15411
2.16	.39140	.41062	.41925	.42354	4.56	1.10980	1.17230	1.18515	1.18021
2.20	.39196	.41145	.42014	.42441	4.60	1.13556	1.19943	1.21229	1.20692
2.24	.39298	.41276	.42151	.42576	4.64	1.16191	1.22719	1.24007	1.23425
2.28	.39446	.41453	.42334	.42757	4.68	1.18888	1.25560	1.26849	1.26220
2.32	.39637	.41674	.42562	.42982	4.72	1.21648	1.28467	1.29756	1.29078
2.36	.39870	.41939	.42833	.43250	4.76	1.24471	1.31440	1.32729	1.32000
2.40	.40143	.42245	.43146	.43560	4.80	1.27358	1.34482	1.35769	1.34988
2.44	.40456	.42591	.43498	.43910	4.84	1.30311	1.37592	1.38878	1.38043
2.48	.40807	.42977	.43891	.44300	4.88	1.33331	1.40772	1.42056	1.41166
2.52	.41195	.43401	.44322	.44728	4.92	1.36419	1.44023	1.45305	1.44357
2.56	.41620	.43864	.44792	.45194	4.96	1.39576	1.47347	1.48626	1.47618
2.60	.42081	.44363	.45299	.45697	5.00	1.42803	1.50745	1.52019	1.50950
2.64	.42577	.44899	.45842	.46236	5.04	1.46101	1.54217	1.55487	1.54355
2.68	.43108	.45471	.46422	.46812	5.08	1.49472	1.57766	1.59031	1.57832
2.72	.43674	.46080	.47038	.47424	5.12	1.52916	1.61392	1.62651	1.61385
2.76	.44275	.46724	.47690	.48070	5.16	1.56435	1.65096	1.66349	1.65013
2.80	.44909	.47403	.48377	.48753	5.20	1.60031	1.68881	1.70126	1.68718
2.84	.45577	.48118	.49100	.49470	5.24	1.63703	1.72747	1.73983	1.72501
2.88	.46280	.48868	.49859	.50223	5.28	1.67454	1.76695	1.77923	1.76364
2.92	.47016	.49654	.50653	.51011	5.32	1.71285	1.80727	1.81945	1.80307
2.96	.47787	.50475	.51482	.51833	5.36	1.75197	1.84845	1.86052	1.84333
3.00	.48591	.51331	.52347	.52691	5.40	1.79192	1.89049	1.90245	1.88442
3.04	.49429	.52224	.53248	.53585	5.44	1.83270	1.93341	1.94524	1.92635
3.08	.50302	.53152	.54184	.54513	5.48	1.87433	1.97722	1.98892	1.96914
3.12	.51210	.54116	.55157	.55478	5.52	1.91682	2.02194	2.03350	2.01281
3.16	.52152	.55116	.56167	.56478	5.56	1.96020	2.06759	2.07900	2.05736
3.20	.53129	.56154	.57213	.57515	5.60	2.00446	2.11417	2.12542	2.10281
3.24	.54142	.57228	.58296	.58588	5.64	2.04963	2.16170	2.17278	2.14918
3.28	.55191	.58340	.59416	.59698	5.68	2.09572	2.21020	2.22110	2.19647
3.32	.56275	.59489	.60574	.60846	5.72	2.14274	2.25968	2.27038	2.24471
3.36	.57396	.60677	.61771	.62031	5.76	2.19070	2.31017	2.32067	2.29392

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TABLE I - VARIATION OF $\underline{E}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[\underline{E} = e^{-\int_1^M \varphi \, dM_1}\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
5.80	2.23963	2.36166	2.37195	2.34408	8.20	7.58628	7.99306	7.96007	7.78500
5.84	2.28954	2.41418	2.42424	2.39523	8.24	7.72817	8.14271	8.10829	7.92893
5.88	2.34044	2.46774	2.47757	2.44738	8.28	7.87226	8.29469	8.25883	8.07509
5.92	2.39235	2.52235	2.53194	2.50055	8.32	8.01858	8.44904	8.41170	8.22350
5.96	2.44527	2.57805	2.58737	2.55475	8.36	8.16716	8.60578	8.56692	8.37419
6.00	2.49924	2.63483	2.64389	2.60999	8.40	8.31802	8.76494	8.72454	8.52719
6.04	2.55426	2.69273	2.70150	2.66630	8.44	8.47120	8.92655	8.88458	8.68252
6.08	2.61034	2.75175	2.76022	2.72368	8.48	8.62670	9.09064	9.04706	8.84022
6.12	2.66751	2.81190	2.82007	2.78216	8.52	8.78457	9.25724	9.21202	9.00030
6.16	2.72578	2.87322	2.88106	2.84174	8.56	8.94484	9.42637	9.37948	9.16281
6.20	2.78517	2.93571	2.94322	2.90246	8.60	9.10752	9.59807	9.54948	9.32776
6.24	2.84569	2.99940	3.00655	2.96431	8.64	9.27264	9.77237	9.72204	9.49518
6.28	2.90736	3.06429	3.07108	3.02733	8.68	9.44024	9.94929	9.89719	9.66511
6.32	2.97019	3.13042	3.13683	3.09151	8.72	9.61034	10.12886	10.07496	9.83757
6.36	3.03421	3.19779	3.20380	3.15690	8.76	9.78297	10.31112	10.25539	10.01258
6.40	3.09943	3.26642	3.27203	3.22349	8.80	9.95816	10.49610	10.43850	10.19019
6.44	3.16586	3.33633	3.34152	3.29131	8.84	10.13594	10.68383	10.62432	10.37042
6.48	3.23353	3.40755	3.41230	3.36037	8.88	10.31633	10.87434	10.81289	10.55329
6.52	3.30245	3.48008	3.48438	3.43069	8.92	10.49937	11.06766	11.00423	10.73885
6.56	3.37264	3.55396	3.55778	3.50230	8.96	10.68508	11.26382	11.19838	10.92711
6.60	3.44412	3.62918	3.63252	3.57520	9.00	10.87350	11.46286	11.39538	11.11812
6.64	3.51690	3.70579	3.70862	3.64942	9.04	11.06465	11.66481	11.59524	11.31190
6.68	3.59101	3.78379	3.78610	3.72497	9.08	11.25857	11.86969	11.79800	11.50847
6.72	3.66646	3.86320	3.86498	3.80188	9.12	11.45528	12.07754	12.00369	11.70788
6.76	3.74327	3.94405	3.94527	3.88015	9.16	11.65482	12.28840	12.21236	11.91015
6.80	3.82146	4.02636	4.02701	3.95982	9.20	11.85722	12.50230	12.42402	12.11532
6.84	3.90104	4.11014	4.11019	4.04089	9.24	12.06250	12.71926	12.63872	12.32341
6.88	3.98205	4.19541	4.19486	4.12340	9.28	12.27070	12.93934	12.85648	12.53446
6.92	4.06449	4.28220	4.28102	4.20735	9.32	12.48184	13.16255	13.07734	12.74851
6.96	4.14839	4.37052	4.36870	4.29277	9.36	12.69597	13.38893	13.30134	12.96557
7.00	4.23376	4.46041	4.45792	4.37968	9.40	12.91311	13.61853	13.52850	13.18570
7.04	4.32063	4.55187	4.54869	4.46809	9.44	13.13329	13.85136	13.75887	13.40891
7.08	4.40901	4.64493	4.64105	4.55804	9.48	13.35655	14.08747	13.99247	13.63525
7.12	4.49894	4.73961	4.73501	4.64953	9.52	13.58292	14.32690	14.22935	13.86475
7.16	4.59041	4.83593	4.83059	4.74259	9.56	13.81243	14.56967	14.46953	14.09743
7.20	4.68347	4.93392	4.92781	4.83724	9.60	14.04512	14.81582	14.71305	14.33334
7.24	4.77812	5.03360	5.02670	4.93350	9.64	14.28101	15.06540	14.95995	14.57251
7.28	4.87439	5.13499	5.12727	5.03140	9.68	14.52015	15.31843	15.21027	14.81497
7.32	4.97230	5.23810	5.22956	5.13094	9.72	14.76256	15.57495	15.46403	15.06076
7.36	5.07187	5.34298	5.33358	5.23216	9.76	15.00828	15.83500	15.72128	15.30992
7.40	5.17313	5.44962	5.43935	5.33508	9.80	15.25735	16.09861	15.98205	15.56247
7.44	5.27608	5.55807	5.54691	5.43972	9.84	15.50979	16.36583	16.24638	15.81846
7.48	5.38077	5.66835	5.65626	5.54609	9.88	15.76564	16.63669	16.51431	16.07791
7.52	5.48720	5.78047	5.76744	5.65423	9.92	16.02494	16.91123	16.78588	16.34088
7.56	5.59540	5.89446	5.88046	5.76416	9.96	16.28772	17.18948	17.06111	16.60738
7.60	5.70539	6.01035	5.99535	5.87589	10.00	16.55401	17.47149	17.34005	16.87747
7.64	5.81720	6.12816	6.11214	5.98945					
7.68	5.93085	6.24791	6.23086	6.10487					
7.72	6.04636	6.36963	6.35151	6.22217					
7.76	6.16375	6.49334	6.47413	6.34137					
7.80	6.28305	6.61907	6.59874	6.46249					
7.84	6.40429	6.74684	6.72537	6.58557					
7.88	6.52747	6.87669	6.85405	6.71061					
7.92	6.65264	7.00863	6.98479	6.83766					
7.96	6.77981	7.14269	7.11763	6.96672					
8.00	6.90901	7.27889	7.25258	7.09784					
8.04	7.04026	7.41727	7.38968	7.23102					
8.08	7.17358	7.55785	7.52895	7.36631					
8.12	7.30901	7.70066	7.67042	7.50371					
8.16	7.44657	7.84572	7.81412	7.64327					

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TABLE II - VARIATION OF $\underline{F}$ WITH MACH NUMBER
M AND VELOCITY-PROFILE PARAMETER N

$$\left[\underline{F} \equiv e^{\int_{0.100}^{M} \varphi dM_1}\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	1.00000	1.00000	1.00000	1.00000
.200	10.34448	9.56047	9.15004	8.89591
.300	39.68497	35.04360	32.70139	31.28207
.400	100.67640	86.12166	78.96629	74.69695
.500	202.51727	109.11741	153.02743	143.53902
.600	350.36128	287.03727	257.03315	239.51305
.700	544.60092	439.26097	390.03557	361.52642
.800	780.98726	621.77891	548.27530	506.01402
.900	1060.19229	827.91431	725.83398	667.52563
1.000	1367.58348	1049.26411	915.43551	839.44246

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TABLE II - VARIATION OF $\underline{F}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[\underline{F} = e^{\int_1^M \phi dM_1} \right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	1.00000	1.00000	1.00000	1.00000	3.40	1.70781	1.61541	1.58715	1.58093
1.04	1.09013	1.08649	1.08463	1.08353	3.44	1.67363	1.58304	1.55568	1.55001
1.08	1.18099	1.17334	1.16946	1.16717	3.48	1.63977	1.55098	1.52451	1.51938
1.12	1.27198	1.26000	1.25397	1.25043	3.52	1.60626	1.51927	1.49367	1.48905
1.16	1.36254	1.34594	1.33764	1.33280	3.56	1.57314	1.48792	1.46318	1.45906
1.20	1.45213	1.43067	1.42001	1.41382	3.60	1.54041	1.45696	1.43306	1.42943
1.24	1.54024	1.51371	1.50062	1.49306	3.64	1.50810	1.42641	1.40332	1.40016
1.28	1.62638	1.59463	1.57906	1.57013	3.68	1.47623	1.39627	1.37400	1.37129
1.32	1.71010	1.67302	1.65496	1.64465	3.72	1.44482	1.36658	1.34509	1.34281
1.36	1.79101	1.74853	1.72797	1.71630	3.76	1.41388	1.33733	1.31661	1.31475
1.40	1.86874	1.82084	1.79780	1.78481	3.80	1.38342	1.30855	1.28857	1.28712
1.44	1.94298	1.88966	1.86419	1.84992	3.84	1.35345	1.28023	1.26098	1.25992
1.48	2.01346	1.95478	1.92694	1.91143	3.88	1.32397	1.25239	1.23384	1.23315
1.52	2.07995	2.01599	1.98585	1.96917	3.92	1.29501	1.22502	1.20717	1.20684
1.56	2.14226	2.07315	2.04079	2.02301	3.96	1.26655	1.19815	1.18097	1.18097
1.60	2.20024	2.12613	2.09166	2.07286	4.00	1.23861	1.17176	1.15523	1.15556
1.64	2.25380	2.17485	2.13839	2.11864	4.04	1.21119	1.14586	1.12996	1.13061
1.68	2.30286	2.21928	2.19095	2.16033	4.08	1.18428	1.12045	1.10517	1.10612
1.72	2.34739	2.25939	2.21932	2.19793	4.12	1.15790	1.09553	1.08085	1.08208
1.76	2.38739	2.29520	2.25352	2.23145	4.16	1.13203	1.07110	1.05700	1.05850
1.80	2.42288	2.32676	2.28361	2.26094	4.20	1.10667	1.04716	1.03362	1.03538
1.84	2.45392	2.35412	2.30964	2.28646	4.24	1.08183	1.02371	1.01071	1.01271
1.88	2.48058	2.37737	2.33170	2.30811	4.28	1.05750	1.00074	.98826	.99049
1.92	2.50297	2.39661	2.34990	2.32599	4.32	1.03367	.97824	.96627	.96872
1.96	2.52120	2.41197	2.36435	2.34020	4.36	1.01035	.95622	.94474	.94740
2.00	2.53540	2.42356	2.37518	2.35087	4.40	.98752	.93466	.92367	.92652
2.04	2.54571	2.43155	2.38254	2.35815	4.44	.96518	.91357	.90304	.90607
2.08	2.55229	2.43606	2.38656	2.36218	4.48	.94333	.89294	.88285	.88606
2.12	2.55531	2.43728	2.38740	2.36309	4.52	.92196	.87276	.86310	.86647
2.16	2.55492	2.43535	2.38522	2.36106	4.56	.90106	.85303	.94378	.84730
2.20	2.55131	2.43044	2.38018	2.35623	4.60	.88063	.83373	.82488	.82855
2.24	2.54465	2.42273	2.37244	2.34877	4.64	.86065	.81487	.30640	.81021
2.28	2.53512	2.41238	2.36217	2.33882	4.68	.84113	.79643	.78834	.79227
2.32	2.52290	2.39955	2.34953	2.32656	4.72	.82205	.77841	.77068	.77473
2.36	2.50816	2.38442	2.33467	2.31212	4.76	.80340	.76080	.75342	.75757
2.40	2.49108	2.36715	2.31775	2.29568	4.80	.78519	.74360	.73654	.74080
2.44	2.47183	2.34790	2.29894	2.27737	4.84	.76739	.72679	.72006	.72441
2.48	2.45057	2.32682	2.27837	2.25734	4.88	.75001	.71037	.70395	.70839
2.52	2.42748	2.30407	2.25619	2.23574	4.92	.73304	.59433	.68821	.69273
2.56	2.40269	2.27980	2.23255	2.21270	4.96	.71646	.67867	.67283	.67743
2.60	2.37638	2.25413	2.20757	2.18833	5.00	.70027	.56337	.65781	.66247
2.64	2.34868	2.22722	2.18140	2.16280	5.04	.68446	.64844	.64314	.64786
2.68	2.31973	2.19919	2.15415	2.13620	5.08	.66902	.63385	.62881	.63358
2.72	2.28968	2.17016	2.12593	2.10866	5.12	.65395	.61961	.61481	.61964
2.76	2.25863	2.14025	2.09688	2.08028	5.16	.63924	.60571	.60115	.60601
2.80	2.22672	2.10957	2.06708	2.05117	5.20	.62488	.59213	.58780	.59271
2.84	2.19407	2.07823	2.03664	2.02142	5.24	.61086	.57888	.57477	.57971
2.88	2.16077	2.04632	2.00566	1.99113	5.28	.59718	.56595	.56204	.56701
2.92	2.12693	2.01394	1.97423	1.96038	5.32	.58382	.55332	.54962	.55461
2.96	2.09264	1.98119	1.94242	1.92926	5.36	.57079	.54099	.53748	.54250
3.00	2.05800	1.94813	1.91032	1.89785	5.40	.55806	.52896	.52564	.53067
3.04	2.02309	1.91485	1.87801	1.86621	5.44	.54564	.51722	.51407	.51912
3.08	1.98798	1.88141	1.84555	1.83441	5.48	.53352	.50576	.50278	.50784
3.12	1.95276	1.84789	1.81300	1.80252	5.52	.52170	.49457	.49176	.49682
3.16	1.91748	1.81434	1.78042	1.77069	5.56	.51015	.48366	.48100	.48606
3.20	1.88220	1.78083	1.74787	1.73868	5.60	.49889	.47300	.47050	.47555
3.24	1.84699	1.74739	1.71540	1.70683	5.64	.48789	.46260	.46024	.46529
3.28	1.81190	1.71410	1.68305	1.67509	5.68	.47716	.45245	.45023	.45528
3.32	1.77698	1.68097	1.65087	1.64350	5.72	.46669	.44254	.44045	.44549
3.36	1.74227	1.64806	1.61889	1.61210	5.76	.45647	.43287	.43091	.43594

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TABLE II - VARIATION OF $\underline{F}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[\underline{F} = e^{\int_1^M \varphi dM_1}\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N: 5	7	9	11
5.80	0.44650	0.42343	0.42159	0.42661
5.84	.43677	.41422	.41250	.41750
5.88	.42727	.40523	.40362	.40860
5.92	.41800	.39646	.39495	.39991
5.96	.40895	.38789	.38649	.39143
6.00	.40012	.37953	.37823	.38314
6.04	.39150	.37137	.37017	.37505
6.08	.38309	.36341	.36229	.36715
6.12	.37488	.35563	.35460	.35943
6.16	.36687	.34804	.34709	.35190
6.20	.35904	.34063	.33976	.34454
6.24	.35141	.33340	.33261	.33735
6.28	.34396	.32634	.32562	.33033
6.32	.33668	.31945	.31879	.32347
6.36	.32958	.31272	.31213	.31677
6.40	.32264	.30615	.30562	.31022
6.44	.31587	.29973	.29926	.30383
6.48	.30926	.29347	.29306	.29759
6.52	.30281	.28735	.28700	.29149
6.56	.29650	.28138	.28107	.28553
6.60	.29035	.27554	.27529	.27971
6.64	.28434	.26985	.26964	.27402
6.68	.27847	.26429	.26412	.26846
6.72	.27274	.25885	.25873	.26303
6.76	.26715	.25355	.25347	.25772
6.80	.26168	.24836	.24832	.25254
6.84	.25634	.24330	.24330	.24747
6.88	.25113	.23836	.23839	.24252
6.92	.24603	.23352	.23359	.23768
6.96	.24106	.22881	.22890	.23295
7.00	.23620	.22419	.22432	.22833
7.04	.23145	.21969	.21984	.22381
7.08	.22681	.21529	.21547	.21939
7.12	.22227	.21099	.21119	.21508
7.16	.21785	.20679	.20701	.21086
7.20	.21352	.20268	.20293	.20673
7.24	.20929	.19866	.19894	.20270
7.28	.20515	.19474	.19504	.19875
7.32	.20111	.19091	.19122	.19490
7.36	.19717	.18716	.18749	.19113
7.40	.19331	.18350	.18385	.18744
7.44	.18953	.17992	.18028	.18383
7.48	.18585	.17642	.17680	.18031
7.52	.18224	.17300	.17339	.17686
7.56	.17872	.16965	.17005	.17349
7.60	.17527	.16638	.16680	.17019
7.64	.17190	.16318	.16361	.16696
7.68	.16861	.16005	.16049	.16380
7.72	.16539	.15700	.15744	.16072
7.76	.16224	.15400	.15446	.15770
7.80	.15916	.15108	.15154	.15474
7.84	.15615	.14822	.14869	.15185
7.88	.15320	.14542	.14590	.14902
7.92	.15032	.14268	.14317	.14625
7.96	.14750	.14000	.14050	.14354
8.00	.14474	.13738	.13788	.14089
8.04	.14204	.13482	.13532	.13829
8.08	.13940	.13231	.13282	.13575
8.12	.13682	.12986	.13037	.13327
8.16	.13429	.12746	.12797	.13083

Mach number M	Velocity-profile parameter, N: 5	7	9	11
8.20	0.13182	0.12511	0.12563	0.12845
8.24	.12940	.12281	.12333	.12612
8.28	.12703	.12056	.12108	.12384
8.32	.12471	.11836	.11888	.12160
8.36	.12244	.11620	.11673	.11942
8.40	.12022	.11409	.11462	.11727
8.44	.11805	.11203	.11255	.11517
8.48	.11592	.11000	.11053	.11312
8.52	.11384	.10802	.10855	.11111
8.56	.11180	.10609	.10662	.10914
8.60	.10980	.10419	.10472	.10721
8.64	.10784	.10233	.10286	.10532
8.68	.10593	.10051	.10104	.10347
8.72	.10405	.09873	.09926	.10165
8.76	.10222	.09698	.09751	.09987
8.80	.10042	.09527	.09580	.09813
8.84	.09866	.09360	.09412	.09643
8.88	.09693	.09196	.09248	.09476
8.92	.09524	.09035	.09087	.09312
8.96	.09359	.08878	.08930	.09152
9.00	.09197	.08724	.08775	.08994
9.04	.09038	.08573	.08624	.08840
9.08	.08882	.08425	.08476	.08689
9.12	.08730	.08280	.08331	.08541
9.16	.08580	.08138	.08188	.08396
9.20	.08434	.07999	.08049	.08254
9.24	.08290	.07862	.07912	.08115
9.28	.08150	.07728	.07778	.07978
9.32	.08012	.07597	.07647	.07844
9.36	.07877	.07469	.07518	.07713
9.40	.07744	.07343	.07392	.07584
9.44	.07614	.07220	.07268	.07458
9.48	.07487	.07099	.07147	.07334
9.52	.07362	.06980	.07028	.07213
9.56	.07240	.06864	.06911	.07094
9.60	.07120	.06750	.06797	.06977
9.64	.07002	.06638	.06685	.06862
9.68	.06887	.06528	.06575	.06750
9.72	.06774	.06421	.06467	.06640
9.76	.06663	.06315	.06361	.06532
9.80	.06554	.06212	.06257	.06426
9.84	.06448	.06110	.06155	.06322
9.88	.06343	.06011	.06055	.06220
9.92	.06240	.05913	.05957	.06120
9.96	.06140	.05818	.05861	.06021
10.00	.06041	.05724	.05767	.05925

TABLE III - VARIATION OF $\underline{I}$ WITH MACH NUMBER

M AND VELOCITY-PROFILE PARAMETER N

$$\left[\underline{I} \equiv \int_{0.100}^{M} \psi_{am}\, e^{\int_{0.100}^{M_1} \varphi dM_1} dM_1\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	0	0	0	0
.200	4.91759	5.68978	6.55166	7.44960
.300	28.29925	31.37242	35.27697	39.50493
.400	94.20004	101.16754	111.76809	123.75784
.500	235.22199	246.43462	268.52546	294.70417
.600	489.50037	502.58784	541.52109	590.03396
.700	897.01022	905.54650	966.53830	1046.79233
.800	1495.82853	1488.32157	1575.78838	1697.78027
.900	2320.09720	2278.20734	2395.19839	2568.97270
1.000	3408.95820	3294.78879	3442.57460	3677.72994

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TABLE III - VARIATION OF $\underline{I}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[\underline{I} = \int_1^M v_{am}\, e^{\int_1^{M_1} \varphi dM_1} dM_1 \right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	0	0	0	0	3.40	48.70297	54.31373	61.15168	68.48143
1.04	.37362	.45064	.52988	.61009	3.44	49.42141	55.08014	61.99307	69.40834
1.08	.77928	.93786	1.10143	1.26716	3.48	50.12821	55.83334	62.81947	70.31840
1.12	1.21723	1.46173	1.71458	1.97102	3.52	50.82340	56.57342	63.63090	71.21173
1.16	1.68751	2.02209	2.36903	2.72123	3.56	51.50703	57.30045	64.42775	72.08850
1.20	2.18998	2.61859	3.06422	3.51709	3.60	52.17917	58.01454	65.20990	72.94888
1.24	2.72436	3.25067	3.79940	4.35764	3.64	52.83989	58.71579	65.97758	73.79303
1.28	3.29018	3.91762	4.57362	5.24172	3.68	53.48927	59.40435	66.73093	74.62114
1.32	3.88683	4.61856	5.38577	6.16799	3.72	54.12742	60.08033	67.47012	75.43341
1.36	4.51355	5.35243	6.23454	7.13490	3.76	54.75443	60.74387	68.19533	76.23005
1.40	5.16947	6.11807	7.11850	8.14077	3.80	55.37041	61.39513	68.90674	77.01127
1.44	5.85359	6.91419	8.03609	9.18377	3.84	55.97547	62.03425	69.60453	77.77728
1.48	6.56480	7.73941	8.98564	10.26195	3.88	56.56973	62.66141	70.28889	78.52839
1.52	7.30191	8.59223	9.96540	11.37328	3.92	57.15332	63.27675	70.96002	79.26454
1.56	8.06364	9.47110	10.97351	12.51564	3.96	57.72637	63.88043	71.61812	79.98627
1.60	8.84867	10.37442	12.00810	13.68688	4.00	58.28903	64.47263	72.26340	80.69371
1.64	9.65561	11.30053	13.06724	14.88477	4.04	58.84142	65.05352	72.89605	81.38708
1.68	10.48304	12.24773	14.14896	16.10708	4.08	59.38368	65.62327	73.51626	82.06662
1.72	11.32950	13.21432	15.25130	17.35156	4.12	59.91596	66.18207	74.12425	82.73257
1.76	12.19354	14.19861	16.37230	18.61605	4.16	60.43840	66.73009	74.72023	83.38517
1.80	13.07368	15.19888	17.51001	19.89829	4.20	60.95116	67.26750	75.30442	84.02466
1.84	13.96843	16.21344	18.66250	21.19611	4.24	61.45439	67.79448	75.87701	84.65128
1.88	14.87633	17.24063	19.82788	22.50739	4.28	61.94823	68.31122	76.43822	85.26526
1.92	15.79593	18.27879	21.00427	23.83004	4.32	62.43284	68.81789	76.98824	85.86683
1.96	16.72581	19.32632	22.18988	25.16205	4.36	62.90837	69.31467	77.52729	86.45623
2.00	17.66458	20.38167	23.38296	26.50143	4.40	63.37497	69.80174	78.05557	87.03369
2.04	18.61088	21.44334	24.58183	27.84633	4.44	63.83278	70.27927	78.57329	87.59945
2.08	19.56337	22.50986	25.78484	29.19493	4.48	64.28196	70.74744	79.08065	88.15374
2.12	20.52078	23.57983	26.99043	30.54548	4.52	64.72266	71.20643	79.57785	88.69678
2.16	21.48190	24.65190	28.19710	31.89633	4.56	65.15504	71.65643	80.06509	89.22879
2.20	22.44553	25.72478	29.40346	33.24592	4.60	65.57925	72.09758	80.54256	89.75000
2.24	23.41054	26.79727	30.60815	34.59277	4.64	65.99543	72.53007	81.01046	90.26064
2.28	24.37584	27.86818	31.80990	35.93540	4.68	66.40372	72.95406	81.46898	90.76092
2.32	25.34042	28.93644	33.00750	37.27270	4.72	66.80428	73.36972	81.91831	91.25104
2.36	26.30329	30.00100	34.19982	38.60324	4.76	67.19725	73.77721	82.35864	91.73122
2.40	27.26353	31.06090	35.38581	39.92592	4.80	67.58278	74.17669	82.79016	92.20168
2.44	28.22027	32.11523	36.56449	41.23967	4.84	67.96099	74.56833	83.21304	92.66260
2.48	29.17271	33.16314	37.73495	42.54351	4.88	68.33203	74.95229	83.62747	93.11419
2.52	30.12008	34.20384	38.89634	43.83652	4.92	68.69604	75.32871	84.03361	93.55664
2.56	31.06166	35.23660	40.04787	45.11785	4.96	69.05316	75.69776	84.43164	93.99017
2.60	31.99680	36.26076	41.18884	46.38674	5.00	69.40352	76.05958	84.82172	94.41494
2.64	32.92488	37.27568	42.31860	47.64249	5.04	69.74727	76.41433	85.20404	94.83117
2.68	33.84535	38.28081	43.43655	48.88447	5.08	70.08453	76.76215	85.57877	95.23902
2.72	34.75767	39.27563	44.54215	50.11209	5.12	70.41540	77.10317	85.94604	95.63865
2.76	35.66137	40.25966	45.63491	51.32485	5.16	70.74003	77.43754	86.30602	96.03027
2.80	36.55601	41.23249	46.71441	52.52229	5.20	71.05854	77.76540	86.65887	96.41405
2.84	37.44120	42.19376	47.78028	53.70403	5.24	71.37106	78.08690	87.00473	96.79015
2.88	38.31659	43.14313	48.83216	54.86972	5.28	71.67772	78.40217	87.34379	97.15876
2.92	39.18186	44.08030	49.86977	56.01906	5.32	71.97863	78.71132	87.67617	97.52003
2.96	40.03673	45.00501	50.89285	57.15178	5.36	72.27390	79.01449	88.00200	97.87410
3.00	40.88095	45.91705	51.90120	58.26768	5.40	72.56365	79.31182	88.32144	98.22115
3.04	41.71431	46.81623	52.89466	59.36660	5.44	72.84798	79.60341	88.63460	98.56132
3.08	42.53662	47.70240	53.87308	60.44841	5.48	73.12701	79.88940	88.94165	98.89477
3.12	43.34771	48.57544	54.83635	61.51300	5.52	73.40084	80.16989	89.24269	99.22164
3.16	44.14744	49.43524	55.78437	62.56031	5.56	73.66958	80.44501	89.53788	99.54208
3.20	44.93572	50.28173	56.71711	63.59031	5.60	73.93334	80.71488	89.82734	99.85623
3.24	45.71245	51.11487	57.63455	64.60300	5.64	74.19222	80.97961	90.11119	100.16423
3.28	46.47758	51.93463	58.53669	65.59840	5.68	74.44633	81.23930	90.38955	100.46622
3.32	47.23105	52.74101	59.42355	66.57655	5.72	74.69575	81.49405	90.66253	100.76232
3.36	47.97285	53.53403	60.29520	67.53753	5.76	74.94058	81.74397	90.93026	101.05266

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TABLE III - VARIATION OF $\underline{I}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[\underline{I} \equiv \int_1^M v_{am}\, e^{\int_1^{M_1} \varphi\, dM_1}\, dM_1\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N: 5	7	9	11
5.80	75.18093	81.98918	91.19285	101.33738
5.84	75.41687	82.22976	91.45040	101.61658
5.88	75.64849	82.46581	91.70303	101.89038
5.92	75.87589	82.69744	91.95086	102.15893
5.96	76.09915	82.92473	92.19397	102.42231
6.00	76.31836	83.14779	92.43247	102.68065
6.04	76.53361	83.36669	92.66647	102.93406
6.08	76.74498	83.58153	92.89606	103.18265
6.12	76.95254	83.79239	93.12132	103.42652
6.16	77.15636	83.99935	93.34236	103.66578
6.20	77.35653	84.20249	93.55926	103.90052
6.24	77.55312	84.40190	93.77213	104.13083
6.28	77.74621	84.59767	93.98104	104.35682
6.32	77.93588	84.78987	94.18609	104.57860
6.36	78.12218	84.97857	94.38735	104.79[illegible]24
6.40	78.30519	85.16384	94.58489	105.00983
6.44	78.48497	85.34575	94.77880	105.21946
6.48	78.66160	85.52438	94.96917	105.42521
6.52	78.83513	85.69979	95.15606	105.62717
6.56	79.00563	85.87205	95.33954	105.82543
6.60	79.17317	86.04123	95.51969	106.02006
6.64	79.33779	86.20739	95.69658	106.21112
6.68	79.49956	86.37060	95.87029	106.39871
6.72	79.65853	86.53092	96.04087	106.58290
6.76	79.81475	86.68839	96.20838	106.76375
6.80	79.96829	86.84309	96.37290	106.94134
6.84	80.11921	86.99508	96.53448	107.11573
6.88	80.26755	87.14440	96.69320	107.28700
6.92	80.41337	87.29112	96.84911	107.45521
6.96	80.55672	87.43529	97.00227	107.62043
7.00	80.69865	87.57695	97.15274	107.78272
7.04	80.83620	87.71616	97.30057	107.94214
7.08	80.97241	87.85296	97.44581	108.09874
7.12	81.10634	87.98742	97.58852	108.25260
7.16	81.23802	88.11958	97.72876	108.40376
7.20	81.36751	88.24947	97.86657	108.55228
7.24	81.49466	88.37715	98.00200	108.69822
7.28	81.62010	88.50266	98.13510	108.84162
7.32	81.74327	88.62605	98.26592	108.98254
7.36	81.86441	88.74737	98.39451	109.12103
7.40	81.98356	88.86664	98.52090	109.25714
7.44	82.10077	88.98391	98.64514	109.39093
7.48	82.21606	89.09923	98.76728	109.52244
7.52	82.32949	89.21263	98.88735	109.65171
7.56	82.44108	89.32414	99.00540	109.77878
7.60	82.55087	89.43381	99.12147	109.90370
7.64	82.65889	89.54167	99.23560	110.02652
7.68	82.76517	89.64776	99.34783	110.14728
7.72	82.86975	89.75211	99.45820	110.26601
7.76	82.97266	89.85476	99.56674	110.38276
7.80	83.07394	89.95573	99.67350	110.49758
7.84	83.17361	90.05506	99.77851	110.61049
7.88	83.27171	90.15279	99.88180	110.72153
7.92	83.36827	90.24895	99.98339	110.83074
7.96	83.46332	90.34356	100.08333	110.93817
8.00	83.55688	90.43665	100.16165	111.04385
8.04	83.64898	90.52827	100.27838	111.14780
8.08	83.73964	90.61843	100.37356	111.25007
8.12	83.82889	90.70716	100.46721	111.35068
8.16	83.91677	90.79448	100.55936	111.44966
8.20	84.00329	90.88042	100.65004	111.54705
8.24	84.08849	90.96502	100.73927	111.64288
8.28	84.17239	91.04829	100.82709	111.73717
8.32	84.25501	91.13026	100.91352	111.62996
8.36	84.33637	91.21095	100.99860	111.92128
8.40	84.41650	91.29039	101.08234	112.01116
8.44	84.49541	91.36861	101.16477	112.09962
8.48	84.57314	91.44563	101.24592	112.18670
8.52	84.64970	91.52146	101.32581	112.27241
8.56	84.72512	91.59613	101.40446	112.35678
8.60	84.79942	91.66966	101.48190	112.43983
8.64	84.87261	91.74208	101.55815	112.52159
8.68	84.94472	91.81341	101.63323	112.60209
8.72	85.01576	91.88366	101.70716	112.68136
8.76	85.08575	91.95284	101.77996	112.75941
8.80	85.15472	92.02098	101.85165	112.83627
8.84	85.22267	92.08810	101.92226	112.91195
8.88	85.28963	92.15422	101.99180	112.98649
8.92	85.35562	92.21937	102.06029	113.05989
8.96	85.42066	92.28355	102.12776	113.13219
9.00	85.48476	92.34678	102.19422	113.20340
9.04	85.54794	92.40908	102.25968	113.27354
9.08	85.61020	92.47047	102.32418	113.34263
9.12	85.67158	92.53096	102.38772	113.41069
9.16	85.73208	92.59056	102.45032	113.47773
9.20	85.79172	92.64930	102.51201	113.54378
9.24	85.85052	92.70719	102.57280	113.60886
9.28	85.90848	92.76424	102.63270	113.67298
9.32	85.96563	92.82046	102.69171	113.73616
9.36	86.02198	92.87588	102.74986	113.79841
9.40	86.07754	92.93051	102.80717	113.85976
9.44	86.13232	92.98436	102.86366	113.92021
9.48	86.18634	93.03744	102.91934	113.97979
9.52	86.23961	93.08977	102.97422	114.03850
9.56	86.29215	93.14136	103.02831	114.09637
9.60	86.34397	93.19223	103.08163	114.15342
9.64	86.39508	93.24239	103.13420	114.20964
9.68	86.44548	93.29184	103.18603	114.26506
9.72	86.49519	93.34060	103.23713	114.31969
9.76	86.54423	93.28868	103.28751	114.37355
9.80	86.59261	93.43610	103.33718	114.42665
9.84	86.64033	93.48286	103.38610	114.47900
9.88	86.68740	93.52897	103.43445	114.53061
9.92	86.73384	93.57445	103.48207	114.58150
9.96	86.77965	93.61932	103.52903	114.63169
10.00	86.82485	93.66357	103.57534	114.68118

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TABLE IV - VARIATION OF $\underline{J}$ WITH MACH NUMBER

M AND VELOCITY-PROFILE PARAMETER N

$$\left[\underline{J} \equiv \int_{0.100}^{M} \psi_{am}\, e^{-\int_{0.100}^{M_1} \varphi dM_1}\, dM_1\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	0	0	0	0
.200	.3985909	.5004917	.6032484	.70638
.300	.4514030	.5717316	.6925810	.81366
.400	.4672274	.5939497	.7210622	.84835
.500	.4739628	.6036716	.7337139	.86391
.600	.4774799	.6088542	.7405334	.87235
.700	.4795857	.6120071	.7447172	.87755
.800	.4809780	.6141182	.7375368	.88108
.900	.4819700	.6156395	.7495786	.88364
1.000	.4827112	.6168013	.7511439	.88560

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TABLE IV - VARIATION OF $\underline{J}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[\underline{J} \equiv \int_1^M \psi_{am}\, e^{-\int_1^{M_1} \varphi dM_1}\, dM_1\right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
1.00	0	0	0	0
1.04	.34237	.41434	.48806	.56251
1.08	.65715	.79616	.93824	1.08160
1.12	.94841	1.15019	1.35600	1.56347
1.16	1.21952	1.48034	1.74585	2.01327
1.20	1.47327	1.78986	2.11156	2.43531
1.24	1.71200	2.08151	2.45632	2.83323
1.28	1.93771	2.35762	2.78283	3.21011
1.32	2.15209	2.62018	3.09341	3.56858
1.36	2.35658	2.87089	3.39003	3.91092
1.40	2.55244	3.11123	3.67441	4.23910
1.44	2.74075	3.34249	3.94805	4.55482
1.48	2.92245	3.56578	4.21225	4.85959
1.52	3.09837	3.78209	4.46816	5.15471
1.56	3.26923	3.992288	4.71679	5.44134
1.60	3.43570	4.19714	4.95906	5.72052
1.64	3.59835	4.39734	5.19575	5.99318
1.68	3.75770	4.59350	5.42761	6.26014
1.72	3.91423	4.78620	5.65528	6.52214
1.76	4.06836	4.97594	5.87935	6.77986
1.80	4.22046	5.16317	6.10036	7.03392
1.84	4.37089	5.34833	6.31881	7.28489
1.88	4.51999	5.53181	6.53514	7.53329
1.92	4.66806	5.71397	6.74977	7.77959
1.96	4.81537	5.89514	6.96310	8.02423
2.00	4.96218	6.07563	7.17550	8.26762
2.04	5.10875	6.25574	7.38730	8.51015
2.08	5.25531	6.43575	7.59883	8.75219
2.12	5.40208	6.61593	7.81038	8.99408
2.16	5.54927	6.79651	8.02224	9.23615
2.20	5.69708	6.97773	8.23469	9.47870
2.24	5.84570	7.15984	8.44798	9.72202
2.28	5.99531	7.34305	8.66238	9.96639
2.32	6.14610	7.52756	8.87813	10.21210
2.36	6.29824	7.71359	9.09546	10.45940
2.40	6.45191	7.90134	9.31461	10.70855
2.44	6.60727	8.09101	9.53580	10.95979
2.48	6.76448	8.28279	9.75924	11.21337
2.52	6.92372	8.47688	9.98515	11.46953
2.56	7.08514	8.67340	10.21373	11.72851
2.60	7.24890	8.87272	10.44520	11.99054
2.64	7.41517	9.07485	10.67978	12.25584
2.68	7.58410	9.28004	10.91767	12.52463
2.72	7.75585	9.48846	11.15906	12.79713
2.76	7.93058	9.70030	11.40417	13.07358
2.80	8.10846	9.91575	11.65320	13.35420
2.84	8.28964	10.13500	11.90636	13.63920
2.88	8.47428	10.35823	12.16385	13.92880
2.92	8.66254	10.58563	12.42588	14.22323
2.96	8.85459	10.81738	12.69265	14.52271
3.00	9.05060	11.05367	12.96438	14.82746
3.04	9.25075	11.29470	13.24127	15.13771
3.08	9.45519	11.54067	13.52355	15.45369
3.12	9.66411	11.79178	13.81143	15.77564
3.16	9.87768	12.04822	14.10511	16.10378
3.20	10.09608	12.31021	14.40483	16.43835
3.24	10.31949	12.57794	14.71081	16.77958
3.28	10.54811	12.85162	15.02327	17.12772
3.32	10.78212	13.13147	15.34245	17.48300
3.36	11.02171	13.41772	15.66859	17.84569

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
3.40	11.26709	13.71057	16.00192	18.21604
3.44	11.51844	14.01026	16.34268	18.59429
3.48	11.77598	14.31702	16.69113	18.98070
3.52	12.03991	14.63109	17.04750	19.37555
3.56	12.31044	14.95270	17.41206	19.77910
3.60	12.58781	15.28209	17.78507	20.19162
3.64	12.87222	15.61952	18.16679	20.61339
3.68	13.16390	15.96523	18.55749	21.04468
3.72	13.46308	16.31949	18.95745	21.48579
3.76	13.77000	16.68256	19.36695	21.93701
3.80	14.08491	17.05472	19.78627	22.39864
3.84	14.40805	17.43623	20.21571	22.87099
3.88	14.73968	17.82738	20.65557	23.35437
3.92	15.08005	18.22846	21.10616	23.84910
3.96	15.42943	18.63976	21.56778	24.35549
4.00	15.78809	19.06158	22.04075	24.87388
4.04	16.15630	19.49423	22.52540	25.40460
4.08	16.53434	19.93801	23.02205	25.94798
4.12	16.92250	20.39325	23.53103	26.50438
4.16	17.32108	20.86028	24.05270	27.07416
4.20	17.73039	21.33942	24.58740	27.65767
4.24	18.15072	21.83101	25.13550	28.25529
4.28	18.58239	22.33541	25.69736	28.86738
4.32	19.02573	22.85297	26.27335	29.49433
4.36	19.48106	23.38406	26.86385	30..3654
4.40	19.94872	23.92904	27.46924	30.79441
4.44	20.42905	24.48829	28.08993	31.46835
4.48	20.92240	25.06221	28.72633	32.15878
4.52	21.42913	25.65118	29.37884	32.86611
4.56	21.94961	26.25561	30.04788	33.59078
4.60	22.48422	26.87591	30.73389	34.33323
4.64	23.03334	27.51250	31.43730	35.093[illegible]
4.68	23.59736	28.16581	32.15856	35.87326
4.72	24.17666	28.83628	32.89814	36.67179
4.76	24.77170	29.52436	33.65650	37.48995
4.80	25.38285	30.23051	34.43412	38.32824
4.84	26.01055	30.95520	35.23148	39.18715
4.88	26.65524	31.69890	36.04907	40.06717
4.92	27.31735	32.46208	36.88739	40.96882
4.96	27.99737	33.24527	37.74699	41.89266
5.00	28.69572	34.04895	38.62836	42.83918
5.04	29.41291	34.87368	39.53207	43.80899
5.08	30.14942	35.71996	40.45867	44.80262
5.12	30.90569	36.58828	41.40866	45.82057
5.16	31.68227	37.47924	42.38265	46.86348
5.20	32.47967	38.39341	43.38122	47.93194
5.24	33.29842	39.33135	44.40497	49.02656
5.28	34.13910	40.29369	45.45455	50.14800
5.32	35.00220	41.28097	46.53052	51.29683
5.36	35.88826	42.29380	47.63349	52.47367
5.40	36.79790	43.33284	48.76416	53.67922
5.44	37.73166	44.39866	49.92312	54.91407
5.48	38.69017	45.49196	51.11109	56.17897
5.52	39.67398	46.61336	52.32869	57.47453
5.56	40.68377	47.76357	53.57667	58.80153
5.60	41.72016	48.94326	54.85572	60.16067
5.64	42.78378	50.15313	56.16656	61.55265
5.68	43.87528	51.39388	57.50992	62.97822
5.72	44.99531	52.66623	58.88652	64.43812
5.76	46.14456	53.97092	60.29714	65.93312

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TABLE IV - VARIATION OF $\underline{J}$ WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[\underline{J} \equiv \int_1^M v_{am}\, e^{-\int_1^{M_1} \varphi\, dM_1}\, dM_1\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N: 5	7	9	11
5.80	47.32378	55.30876	61.74262	67.46407
5.84	48.53361	56.68046	63.22366	69.03169
5.88	49.77478	58.08678	64.74106	70.63679
5.92	51.04807	59.52860	66.29572	72.28027
5.96	52.35416	61.00664	67.88837	73.96287
6.00	53.69487	62.52180	69.51994	75.68553
6.04	55.06800	64.07494	71.19132	77.44912
6.08	56.47732	65.66688	72.90336	79.25450
6.12	57.92256	67.29841	74.65684	81.10249
6.16	59.40461	68.97051	76.45278	82.99409
6.20	60.92431	70.68408	78.29211	84.93025
6.24	62.48252	72.44005	80.17577	86.91190
6.28	64.08009	74.23935	82.10472	88.94001
6.32	65.71800	76.08305	84.08006	91.01569
6.36	67.39708	77.97201	86.10266	93.13981
6.40	69.11821	79.90720	88.17351	95.31337
6.44	70.88233	81.88965	90.29367	97.53742
6.48	72.69050	83.92049	92.46429	99.81313
6.52	74.54358	86.00065	94.68632	103.14145
6.56	76.44264	88.13129	96.96095	104.52357
6.60	78.28869	80.31349	99.28929	106.96059
6.64	80.38267	92.54826	101.67236	109.45355
6.68	82.42568	94.83681	104.11138	112.00368
6.72	84.51879	97.18029	106.60755	114.61215
6.76	86.66298	99.57975	109.16193	117.28003
6.80	88.85945	102.03549	111.77583	120.00866
6.84	91.10931	104.55171	114.45048	122.79925
6.88	93.41368	107.12663	117.18712	125.65305
6.92	95.77374	109.76249	119.98702	128.57133
6.96	98.19076	112.46068	122.85161	131.55551
7.00	100.66581	115.22235	125.78205	134.60674
7.04	103.20013	118.04884	128.77971	137.72641
7.08	105.79496	120.94147	131.84592	140.91565
7.12	108.45164	123.90171	134.98218	144.17655
7.16	111.17135	126.93081	138.18977	147.50978
7.20	113.95539	130.03017	141.47010	150.91695
7.24	116.80521	133.20136	144.82478	154.39967
7.28	119.72201	136.44568	148.25511	157.95924
7.32	122.70731	139.76478	151.76277	161.59732
7.36	125.76250	143.16011	155.34925	165.31542
7.40	128.88881	146.63302	159.01592	169.11489
7.44	132.08787	150.18530	162.76457	172.99751
7.48	135.36117	153.81850	166.59680	176.96489
7.52	138.71012	157.53415	170.51417	181.01858
7.56	142.13605	161.33369	174.51809	185.15999
7.60	145.64072	165.21900	178.61052	189.39105
7.64	149.22567	169.19177	182.79314	193.71346
7.68	152.89249	173.25367	187.06767	198.12890
7.72	156.64278	177.40646	191.43588	202.63915
7.76	160.47819	181.65188	195.89954	207.24595
7.80	164.40038	185.99175	200.46047	211.95115
7.84	168.41107	190.42791	205.12056	216.75660
7.88	172.51213	194.96233	209.88181	221.66431
7.92	176.70506	199.59666	214.74590	226.67592
7.96	180.99171	204.33288	219.71478	231.79338
8.00	185.37408	209.17316	224.79067	237.01892
8.04	189.85392	214.11938	229.97550	242.35443
9.08	194.43292	219.17336	235.27107	247.80172
8.12	199.11295	224.33709	240.67943	253.36279
8.16	203.89616	229.61290	246.20292	259.03998
8.20	208.78426	235.00261	251.84339	264.93512
8.24	213.77943	240.50857	257.60321	270.75058
8.28	218.88353	246.13278	263.48439	276.78834
8.32	224.09872	251.87757	269.48930	282.95075
8.36	229.42711	257.74520	275.62019	289.24006
8.40	234.87055	263.73766	281.87910	295.65829
8.44	240.43144	269.85755	288.26865	302.20803
8.48	246.11189	276.10711	294.79111	308.89150
8.52	251.91407	282.48869	301.44884	315.71107
8.56	257.84028	289.00476	308.24435	322.66921
8.60	263.89278	295.65770	315.18005	329.76832
8.64	270.07382	302.45000	322.25841	337.01086
8.68	276.38579	309.38419	329.48201	344.39939
8.72	282.83099	316.46274	336.85336	351.93637
8.76	289.41178	323.68621	344.37502	359.62431
8.80	296.13063	331.06325	352.04964	367.46587
8.84	302.99009	338.59058	359.87999	375.46379
8.88	309.99264	346.27287	367.86876	383.62074
8.92	317.14069	354.11274	376.01859	391.93930
8.96	324.43725	362.11339	384.33271	400.42271
9.00	331.88463	370.27728	392.81361	409.07336
9.04	339.48540	378.60720	401.46408	417.89408
9.08	347.24255	387.10644	410.28742	426.88811
9.12	355.15849	395.77751	419.28617	436.05794
9.16	363.23607	404.62346	428.46343	445.40668
9.20	371.47841	413.64768	437.92263	454.93767
9.24	379.88791	422.85273	447.36631	464.65345
9.28	388.46795	432.24225	457.09813	474.55759
9.32	397.22099	441.81887	467.02075	484.65279
9.36	406.15041	451.58625	477.13781	494.94262
9.40	415.25917	461.54758	487.45260	505.43031
9.44	424.54994	471.70573	497.96794	516.11864
9.48	434.02638	482.06458	508.68776	527.01151
9.52	443.69093	492.62678	519.61476	538.11156
9.56	453.54722	503.39626	530.75287	549.42267
9.60	463.59864	514.37666	542.10574	560.94846
9.64	473.84843	525.57149	553.67689	572.69246
9.68	484.29949	536.98379	565.46936	584.65760
9.72	494.95539	548.61744	577.48716	596.84779
9.76	505.81954	560.47616	589.73391	609.26667
9.80	516.89559	572.56383	602.21356	621.91816
9.84	528.18699	584.88412	614.92980	634.80563
9.88	539.69724	597.44086	627.88645	647.93350
9.92	551.43001	610.23792	641.08744	661.30498
9.96	563.38885	623.27916	654.53663	674.92411
10.00	575.57744	646.56845	668.23791	688.79475

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TABLE V - VARIATION OF MOMENTUM-THICKNESS RATIO f WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N

$$\left[f = \frac{\theta}{\delta}\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	0.11894	0.09715	0.08176	0.07048
.200	.11865	.09695	.08162	.07037
.300	.11816	.09662	.08138	.07019
.400	.11748	.09616	.08105	.06994
.500	.11663	.09557	.08063	.06962
.600	.11560	.09487	.08012	.06924
.700	.11442	.09406	.07953	.06879
.800	.11309	.09315	.07887	.06829
.900	.11162	.09214	.07813	.06772
1.000	.11004	.09104	.07733	.06711

TABLE V - VARIATION OF MOMENTUM-THICKNESS RATIO f WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$\left[f = \frac{\theta}{\delta}\right]$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	0.11004	0.09104	0.07733	0.06711	3.40	0.06441	0.05708	0.05107	0.04617
1.04	.10938	.09058	.07699	.06685	3.44	.06377	.05657	.05066	.04582
1.08	.10870	.09010	.07664	.06658	3.48	.06314	.05607	.05024	.04548
1.12	.10801	.08962	.07628	.06631	3.52	.06251	.05557	.04984	.04514
1.16	.10730	.08912	.07592	.06603	3.56	.06189	.05507	.04943	.04480
1.20	.10658	.08862	.07555	.06574	3.60	.06128	.05458	.04903	.04447
1.24	.10585	.08810	.07516	.06545	3.64	.06067	.05410	.04863	.04413
1.28	.10511	.08758	.07478	.06515	3.68	.06007	.05361	.04823	.04380
1.32	.10435	.08704	.07438	.06485	3.72	.05948	.05314	.04784	.04347
1.36	.10359	.08650	.07398	.06454	3.76	.05889	.05266	.04745	.04314
1.40	.10281	.08595	.07357	.06422	3.80	.05832	.05219	.04706	.04282
1.44	.10203	.08540	.07315	.06390	3.84	.05774	.05173	.04668	.04250
1.48	.10124	.08483	.07273	.06357	3.88	.05718	.05127	.04630	.04217
1.52	.10045	.08427	.07231	.06324	3.92	.05662	.05082	.04592	.04186
1.56	.09965	.08369	.07188	.06291	3.96	.05606	.05037	.04555	.04154
1.60	.09884	.08311	.07144	.06257	4.00	.05551	.04992	.04518	.04123
1.64	.09803	.08253	.07100	.06223	4.04	.05497	.04948	.04481	.04092
1.68	.09721	.08194	.07056	.06188	4.08	.05444	.04904	.04445	.04061
1.72	.09640	.08135	.07011	.06153	4.12	.05391	.04861	.04409	.04030
1.76	.09557	.08075	.06966	.06118	4.16	.05339	.04818	.04373	.04000
1.80	.09475	.08016	.06921	.06083	4.20	.05287	.04775	.04337	.03969
1.84	.09393	.07956	.06875	.06047	4.24	.05236	.04733	.04302	.03939
1.88	.09310	.07895	.06830	.06011	4.28	.05186	.04692	.04267	.03910
1.92	.09228	.07835	.06784	.05974	4.32	.05136	.04651	.04233	.03880
1.96	.09145	.07774	.06737	.05938	4.36	.05087	.04610	.04198	.03851
2.00	.09063	.07714	.06691	.05901	4.40	.05038	.04570	.04164	.03822
2.04	.08980	.07653	.06644	.05864	4.44	.04990	.04530	.04131	.03793
2.08	.08898	.07592	.06598	.05827	4.48	.04942	.04490	.04098	.03765
2.12	.08816	.07532	.06551	.05790	4.52	.04895	.04451	.04065	.03736
2.16	.08734	.07471	.06504	.05753	4.56	.04849	.04412	.04032	.03708
2.20	.08653	.07410	.06457	.05716	4.60	.04803	.04374	.03999	.03680
2.24	.08572	.07350	.06410	.05678	4.64	.04758	.04336	.03967	.03653
2.28	.08491	.07289	.06364	.05641	4.68	.04713	.04299	.03936	.03626
2.32	.08410	.07229	.06317	.05603	4.72	.04669	.04262	.03904	.03598
2.36	.08330	.07168	.06270	.05566	4.76	.04625	.04225	.03873	.03571
2.40	.08250	.07108	.06223	.05528	4.80	.04582	.04189	.03842	.03545
2.44	.08171	.07049	.06176	.05491	4.84	.04539	.04153	.03811	.03518
2.48	.08092	.06989	.06130	.05453	4.88	.04497	.04117	.03781	.03492
2.52	.08014	.06930	.06083	.05416	4.92	.04455	.04082	.03751	.03466
2.56	.07936	.06870	.06037	.05378	4.96	.04414	.04047	.03721	.03440
2.60	.07859	.06812	.05990	.05341	5.00	.04373	.04013	.03692	.03415
2.64	.07782	.06753	.05944	.05304	5.04	.04333	.03979	.03663	.03389
2.68	.07706	.06695	.05898	.05266	5.08	.04293	.03945	.03634	.03364
2.72	.07630	.06637	.05852	.05229	5.12	.04254	.03912	.03605	.03339
2.76	.07555	.06579	.05807	.05192	5.16	.04215	.03879	.03577	.03315
2.80	.07480	.06522	.05761	.05155	5.20	.04177	.03846	.03549	.03290
2.84	.07407	.06465	.05716	.05118	5.24	.04139	.03814	.03521	.03266
2.88	.07333	.06408	.05671	.05081	5.28	.04102	.03782	.03493	.03242
2.92	.07261	.06352	.05626	.05044	5.32	.04065	.03751	.03466	.03218
2.96	.07189	.06296	.05581	.05008	5.36	.04028	.03719	.03439	.03194
3.00	.07117	.06240	.05537	.04972	5.40	.03992	.03688	.03412	.03171
3.04	.07047	.06185	.05493	.04935	5.44	.03956	.03658	.03386	.03148
3.08	.06977	.06131	.05449	.04899	5.48	.03921	.03628	.03359	.03125
3.12	.06907	.06076	.05405	.04863	5.52	.03886	.03598	.03334	.03102
3.16	.06839	.06022	.05362	.04828	5.56	.03852	.03568	.03308	.03079
3.20	.06771	.05969	.05318	.04792	5.60	.03818	.03539	.03282	.03057
3.24	.06703	.05916	.05276	.04757	5.64	.03784	.03510	.03257	.03035
3.28	.06637	.05863	.05233	.04721	5.68	.03751	.03481	.03232	.03013
3.32	.06571	.05811	.05191	.04686	5.72	.03718	.03453	.03207	.02991
3.36	.06505	.05759	.05149	.04651	5.76	.03686	.03425	.03183	.02970

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TABLE V - VARIATION OF MOMENTUM-THICKNESS RATIO f WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[f = \frac{\theta}{\delta}\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
5.80	0.03653	0.03397	0.03159	0.02948	8.20	0.02264	0.02164	0.02060	0.01961
5.84	.03622	.03369	.03135	.02927	8.24	.02248	.02149	.02046	.01948
5.88	.03590	.03342	.03111	.02906	8.28	.02232	.02134	.02033	.01936
5.92	.03559	.03315	.03087	.02885	8.32	.02216	.02120	.02019	.01924
5.96	.03529	.03289	.03064	.02865	8.36	.02200	.02105	.02006	.01912
6.00	.03499	.03262	.03041	.02844	8.40	.02184	.02091	.01993	.01900
6.04	.03469	.03236	.03018	.02824	8.44	.02168	.02077	.01980	.01888
6.08	.03439	.03210	.02995	.02804	8.48	.02153	.02063	.01967	.01876
6.12	.03410	.03185	.02973	.02784	8.52	.02138	.02049	.01954	.01865
6.16	.03381	.03160	.02951	.02764	8.56	.02123	.02035	.01942	.01853
6.20	.03352	.03135	.02929	.02745	8.60	.02108	.02021	.01929	.01841
6.24	.03324	.03110	.02907	.02725	8.64	.02093	.02008	.01917	.01830
6.28	.03296	.03086	.02885	.02706	8.68	.02078	.01994	.01905	.01819
6.32	.03269	.03061	.02864	.02687	8.72	.02064	.01981	.01892	.01808
6.36	.03241	.03037	.02843	.02668	8.76	.02050	.01968	.01880	.01796
6.40	.03214	.03014	.02822	.02649	8.80	.02035	.01955	.01868	.01785
6.44	.03188	.02990	.02801	.02631	8.84	.02021	.01942	.01857	.01774
6.48	.03161	.02967	.02781	.02613	8.88	.02007	.01929	.01845	.01764
6.52	.03135	.02944	.02760	.02594	8.92	.01994	.01916	.01833	.01753
6.56	.03110	.02921	.02740	.02576	8.96	.01980	.01904	.01822	.01742
6.60	.03084	.02899	.02720	.02559	9.00	.01966	.01891	.01810	.01732
6.64	.03059	.02877	.02700	.02541	9.04	.01953	.01879	.01799	.01721
6.68	.03034	.02855	.02681	.02523	9.08	.01940	.01867	.01788	.01711
6.72	.03009	.02833	.02661	.02506	9.12	.01927	.01855	.01776	.01701
6.76	.02985	.02811	.02642	.02489	9.16	.01914	.01843	.01765	.01690
6.80	.02961	.02790	.02623	.02472	9.20	.01901	.01831	.01754	.01680
6.84	.02937	.02769	.02604	.02455	9.24	.01888	.01819	.01744	.01670
6.88	.02914	.02748	.02586	.02438	9.28	.01875	.01807	.01733	.01660
6.92	.02890	.02727	.02567	.02421	9.32	.01863	.01796	.01722	.01650
6.96	.02867	.02707	.02549	.02405	9.36	.01850	.01784	.01711	.01641
7.00	.02844	.02686	.02531	.02389	9.40	.01838	.01773	.01701	.01631
7.04	.02822	.02666	.02513	.02372	9.44	.01826	.01762	.01691	.01621
7.08	.02800	.02646	.02495	.02356	9.48	.01814	.01750	.01680	.01612
7.12	.02778	.02627	.02478	.02341	9.52	.01802	.01739	.01670	.01602
7.16	.02756	.02607	.02460	.02325	9.56	.01790	.01728	.01660	.01593
7.20	.02734	.02588	.02443	.02309	9.60	.01778	.01717	.01650	.01583
7.24	.02713	.02569	.02426	.02294	9.64	.01767	.01707	.01640	.01574
7.28	.02692	.02550	.02409	.02278	9.68	.01755	.01696	.01630	.01565
7.32	.02671	.02531	.02392	.02263	9.72	.01744	.01685	.01620	.01556
7.36	.02650	.02513	.02375	.02248	9.76	.01733	.01675	.01610	.01547
7.40	.02630	.02495	.02359	.02233	9.80	.01721	.01665	.01601	.01538
7.44	.02610	.02476	.02343	.02218	9.84	.01710	.01654	.01591	.01529
7.48	.02590	.02458	.02326	.02204	9.88	.01699	.01644	.01582	.01520
7.52	.02570	.02441	.02310	.02189	9.92	.01689	.01634	.01572	.01511
7.56	.02550	.02423	.02294	.02175	9.96	.01678	.01624	.01563	.01503
7.60	.02531	.02406	.02279	.02161	10.00	.01667	.01614	.01554	.01494
7.64	.02512	.02388	.02263	.02146					
7.68	.02493	.02371	.02248	.02132					
7.72	.02474	.02354	.02232	.02119					
7.76	.02456	.02338	.02217	.02105					
7.80	.02437	.02321	.02202	.02091					
7.84	.02419	.02305	.02187	.02078					
7.88	.02401	.02288	.02173	.02064					
7.92	.02384	.02272	.02158	.02051					
7.96	.02366	.02256	.02144	.02038					
8.00	.02349	.02241	.02129	.02025					
8.04	.02331	.02225	.02115	.02012					
8.08	.02314	.02209	.02101	.01999					
8.12	.02297	.02194	.02087	.01986					
8.16	.02281	.02179	.02073	.01973					

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TABLE VI - VARIATION OF DISPLACEMENT-THICKNESS RATIO g WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N

$$\left[g = \frac{\delta^*}{\delta}\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	0.16708	0.12533	0.10026	0.08353
.200	.16832	.126375	.10115	.08431
.300	.17038	.12811	.10264	.08561
.400	.17324	.13052	.10471	.08742
.500	.17687	.13359	.10735	.08973
.600	.18124	.13728	.11054	.09253
.700	.18631	.14159	.11426	.09579
.800	.19204	.14647	.11848	.09951
.900	.19838	.15189	.12319	.10366
1.000	.20530	.15782	.12836	.10822

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TABLE VI - VARIATION OF DISPLACEMENT-THICKNESS RATIO g WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[g = \frac{\delta^*}{\delta}\right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	0.20530	0.15782	0.12836	0.10822	3.40	0.43230	0.36603	0.31894	0.28336
1.04	.20821	.16033	.13054	.11016	3.44	.43595	.36958	.32234	.28660
1.08	.21120	.16291	.13280	.11215	3.48	.43958	.37312	.32573	.28982
1.12	.21426	.16556	.13512	.11421	3.52	.44319	.37664	.32911	.29305
1.16	.21740	.16828	.13750	.11632	3.56	.44677	.38015	.33248	.29626
1.20	.22061	.17106	.13994	.11849	3.60	.45033	.38364	.33583	.29947
1.24	.22389	.17391	.14244	.12072	3.64	.45387	.38711	.33918	.30267
1.28	.22722	.17681	.14500	.12299	3.68	.45738	.39056	.34251	.30586
1.32	.23062	.17978	.14761	.12532	3.72	.46088	.39400	.34583	.30904
1.36	.23408	.18280	.15028	.12770	3.76	.46434	.39742	.34914	.31221
1.40	.23759	.18587	.15299	.13013	3.80	.46779	.40082	.35243	.31538
1.44	.24115	.18900	.15576	.13261	3.84	.47121	.40421	.35571	.31853
1.48	.24475	.19217	.15857	.13513	3.88	.47460	.40757	.35898	.32168
1.52	.24841	.19539	.16143	.13769	3.92	.47797	.41092	.36223	.32481
1.56	.25210	.19866	.16434	.14030	3.96	.48132	.41425	.36547	.32794
1.60	.25584	.20196	.16728	.14294	4.00	.48464	.41756	.36870	.33105
1.64	.25961	.20531	.17027	.14563	4.04	.48794	.42085	.37191	.33415
1.68	.26341	.20869	.17329	.14835	4.08	.49121	.42412	.37510	.33725
1.72	.26725	.21211	.17635	.15111	4.12	.49446	.42737	.37828	.34033
1.76	.27112	.21557	.17944	.15391	4.16	.49769	.43060	.38145	.34339
1.80	.27501	.21905	.18257	.15674	4.20	.50089	.43381	.38460	.34645
1.84	.27892	.22256	.18573	.15960	4.24	.50407	.43701	.38773	.34950
1.88	.28286	.22610	.18892	.16249	4.28	.50722	.44018	.39085	.35253
1.92	.28682	.22967	.19213	.16541	4.32	.51035	.44334	.39395	.35555
1.96	.29079	.23325	.19537	.16836	4.36	.51345	.44647	.39704	.35855
2.00	.29478	.23686	.19864	.17133	4.40	.51654	.44958	.40011	.36155
2.04	.29878	.24049	.20193	.17433	4.44	.51959	.45268	.40317	.36453
2.08	.30280	.24414	.20524	.17735	4.48	.52263	.45575	.40620	.36750
2.12	.30682	.24780	.20858	.18040	4.52	.52564	.45881	.40923	.37045
2.16	.31085	.25148	.21193	.18346	4.56	.52862	.46184	.41223	.37339
2.20	.31489	.25517	.21530	.18655	4.60	.53158	.46486	.41522	.37632
2.24	.31893	.25888	.21868	.18965	4.64	.53452	.46786	.41819	.37923
2.28	.32297	.26259	.22208	.19278	4.68	.53744	.47083	.42115	.38214
2.32	.32701	.26631	.22549	.19592	4.72	.54033	.47379	.42409	.38502
2.36	.33105	.27004	.22892	.19907	4.76	.54320	.47672	.42701	.38790
2.40	.33509	.27378	.23236	.20224	4.80	.54604	.47964	.42992	.39075
2.44	.33913	.27752	.23580	.20542	4.84	.54887	.48253	.43281	.39360
2.48	.34316	.28126	.23926	.20861	4.88	.55167	.48541	.43568	.39643
2.52	.34718	.28501	.24272	.21182	4.92	.55444	.48827	.43854	.39925
2.56	.35120	.28875	.24619	.21503	4.96	.55720	.49110	.44138	.40205
2.60	.35521	.29250	.24966	.21825	5.00	.55993	.49392	.44420	.40484
2.64	.35921	.29624	.25314	.22149	5.04	.56264	.49672	.44701	.40761
2.68	.36320	.29999	.25662	.22472	5.08	.56533	.49950	.44979	.41037
2.72	.36718	.30373	.26011	.22797	5.12	.56800	.50226	.45257	.41312
2.76	.37114	.30746	.26359	.23122	5.16	.57064	.50500	.45532	.41585
2.80	.37509	.31119	.26708	.23448	5.20	.57327	.50772	.45806	.41856
2.84	.37903	.31492	.27056	.23773	5.24	.57586	.51042	.46078	.42126
2.88	.38296	.31863	.27405	.24100	5.28	.57844	.51310	.46349	.42395
2.92	.38686	.32234	.27753	.24426	5.32	.58100	.51577	.46618	.42662
2.96	.39075	.32605	.28101	.24753	5.36	.58354	.51841	.46885	.42928
3.00	.39463	.32974	.28449	.25079	5.40	.58606	.52104	.47150	.43193
3.04	.39848	.33342	.28797	.25406	5.44	.58855	.52364	.47414	.43455
3.08	.40232	.33709	.29143	.25733	5.48	.59103	.52623	.47676	.43717
3.12	.40614	.34076	.29490	.26059	5.52	.59349	.52880	.47937	.43977
3.16	.40994	.34441	.29836	.26385	5.56	.59592	.53135	.48196	.44235
3.20	.41372	.34804	.30181	.26711	5.60	.59834	.53388	.48453	.44493
3.24	.41747	.35167	.30525	.27037	5.64	.60073	.53640	.48709	.44748
3.28	.42121	.35528	.30869	.27363	5.68	.60310	.53890	.48963	.45002
3.32	.42493	.35888	.31211	.27688	5.72	.60546	.54137	.49215	.45255
3.36	.42863	.36246	.31553	.28012	5.76	.60779	.54383	.49466	.45506

TABLE VI - VARIATION OF DISPLACEMENT-THICKNESS RATIO g WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[g = \frac{\delta^*}{\delta}\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
5.80	0.61012	0.54628	0.49715	0.45756
5.84	.61241	.54870	.49963	.46005
5.88	.61469	.55111	.50209	.46252
5.92	.61695	.55350	.50453	.46497
5.96	.61919	.55587	.50696	.46741
6.00	.62142	.55823	.50937	.46984
6.04	.62362	.56056	.51177	.47225
6.08	.62580	.56288	.51415	.47465
6.12	.62798	.56519	.51651	.47704
6.16	.63012	.56748	.51886	.47941
6.20	.63226	.56975	.52120	.48176
6.24	.63437	.57200	.52352	.48411
6.28	.63647	.57424	.52582	.48643
6.32	.63856	.57646	.52811	.48875
6.36	.64062	.57866	.53038	.49105
6.40	.64267	.58085	.53264	.49334
6.44	.64469	.58302	.53488	.49561
6.48	.64670	.58518	.53711	.49787
6.52	.64871	.58732	.53933	.50011
6.56	.65069	.58944	.54152	.50235
6.60	.65266	.59155	.54371	.50457
6.64	.65460	.59365	.54588	.50677
6.68	.65653	.59572	.54803	.50896
6.72	.65845	.59779	.55018	.51114
6.76	.66035	.59983	.55230	.51331
6.80	.66224	.60187	.55442	.51546
6.84	.66411	.60389	.55651	.51760
6.88	.66596	.60589	.55860	.51972
6.92	.66781	.60788	.56067	.52184
6.96	.66963	.60985	.56273	.52394
7.00	.67145	.61181	.56477	.52602
7.04	.67325	.61376	.56680	.52810
7.08	.67502	.61569	.56882	.53016
7.12	.67680	.61760	.57082	.53221
7.16	.67855	.61951	.57281	.53424
7.20	.68029	.62140	.57478	.53627
7.24	.68201	.62327	.57675	.53828
7.28	.68372	.62513	.57870	.54028
7.32	.68543	.62698	.58063	.54226
7.36	.68711	.62882	.58256	.54424
7.40	.68879	.63064	.58447	.54620
7.44	.69045	.63245	.58636	.54815
7.48	.69209	.63424	.58825	.55008
7.52	.69374	.63602	.59012	.55201
7.56	.69535	.63779	.59198	.55392
7.60	.69696	.63955	.59383	.55582
7.64	.69856	.64129	.59567	.55771
7.68	.70013	.64302	.59749	.55959
7.72	.70171	.64474	.59930	.56146
7.76	.70327	.64645	.60110	.56331
7.80	.70482	.64814	.60289	.56516
7.84	.70635	.64982	.60466	.56699
7.88	.70786	.65149	.60642	.56881
7.92	.70938	.65315	.60818	.57062
7.96	.71088	.65479	.60991	.57241
8.00	.71237	.65643	.61164	.57420
8.04	.71385	.65805	.61336	.57598
8.08	.71530	.65966	.61506	.57774
8.12	.71676	.66126	.61676	.57949
8.16	.71820	.66284	.61844	.58124
8.20	0.71964	0.66442	0.62011	0.58297
8.24	.72106	.66598	.62177	.58469
8.28	.72246	.66754	.62342	.58640
8.32	.72387	.66908	.62506	.58810
8.36	.72525	.67061	.62669	.58979
8.40	.72663	.67213	.62830	.59146
8.44	.72800	.67364	.62991	.59313
8.48	.72934	.67514	.63151	.59479
8.52	.73070	.67663	.63309	.59644
8.56	.73204	.67811	.63466	.59807
8.60	.73337	.67957	.63623	.59970
8.64	.73468	.68103	.63778	.60132
8.68	.73598	.68248	.63932	.60292
8.72	.73729	.68391	.64086	.60452
8.76	.73857	.68534	.64238	.60611
8.80	.73985	.68676	.64389	.60768
8.84	.74112	.68816	.64540	.60925
8.88	.74236	.68956	.64689	.61081
8.92	.74363	.69095	.64837	.61236
8.96	.74486	.69232	.64985	.61389
9.00	.74610	.69369	.65131	.61542
9.04	.74732	.69505	.65277	.61694
9.08	.74852	.69640	.65421	.61845
9.12	.74973	.69774	.65565	.61995
9.16	.75092	.69907	.65707	.62144
9.20	.75212	.70039	.65849	.62292
9.24	.75329	.70170	.65990	.62440
9.28	.75445	.70300	.66130	.62586
9.32	.75564	.70430	.66268	.62732
9.36	.75678	.70558	.66406	.62876
9.40	.75794	.70686	.66544	.63020
9.44	.75907	.70812	.66680	.63163
9.48	.76018	.70938	.66815	.63304
9.52	.76133	.71063	.66950	.63445
9.56	.76243	.71187	.67083	.63586
9.60	.76354	.71311	.67216	.63725
9.64	.76464	.71433	.67348	.63863
9.68	.76570	.71555	.67479	.64001
9.72	.76681	.71675	.67609	.64138
9.76	.76788	.71795	.67738	.64274
9.80	.76895	.71914	.67867	.64409
9.84	.77001	.72033	.67995	.64543
9.88	.77105	.72150	.68122	.64676
9.92	.77211	.72267	.68248	.64809
9.96	.77314	.72383	.68373	.64941
10.00	.77418	.72498	.68497	.65072

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TABLE VII - VARIATION OF SHAPE PARAMETER H WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N

$$\left[H = \frac{\delta^*}{\theta}\right]$$

(a) Subsonic flow.

Mach number M	Velocity-profile parameter, N			
	5	7	9	11
0.100	1.40466	1.29006	1.22618	1.18509
.200	1.41866	1.30353	1.23934	1.19808
.300	1.44198	1.32596	1.26127	1.21969
.400	1.47463	1.35737	1.29199	1.24993
.500	1.51658	1.39773	1.33142	1.28885
.600	1.56785	1.44704	1.37965	1.33629
.700	1.62840	1.50531	1.43663	1.39251
.800	1.69821	1.57249	1.50233	1.45715
.900	1.77728	1.64860	1.57677	1.53071
1.000	1.86559	1.73364	1.65994	1.61262

TABLE VII - VARIATION OF SHAPE PARAMETER H WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Continued

$$\left[H = \frac{\delta^*}{\theta}\right]$$

(b) Supersonic flow.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
1.00	1.8656	1.7336	1.6599	1.6126	3.40	6.7118	6.4125	6.2452	6.1377
1.04	1.9035	1.7701	1.6956	1.6478	3.44	6.8364	6.5330	6.3634	6.2544
1.08	1.9429	1.8080	1.7327	1.6844	3.48	6.9624	6.6548	6.4830	6.3725
1.12	1.9837	1.8474	1.7712	1.7223	3.52	7.0898	6.7780	6.6039	6.4919
1.16	2.0261	1.8882	1.8111	1.7616	3.56	7.2187	6.9027	6.7261	6.6127
1.20	2.0699	1.9303	1.8524	1.8023	3.60	7.3490	7.0287	6.8498	6.7348
1.24	2.1151	1.9739	1.8950	1.8444	3.64	7.4807	7.1560	6.9748	6.8583
1.28	2.1619	2.0190	1.9391	1.8878	3.68	7.6138	7.2848	7.1011	6.9831
1.32	2.2101	2.0654	1.9845	1.9326	3.72	7.7483	7.4150	7.2288	7.1092
1.36	2.2597	2.1132	2.0314	1.9788	3.76	7.8843	7.5465	7.3579	7.2367
1.40	2.3108	2.1625	2.0796	2.0263	3.80	8.0217	7.6794	7.4883	7.3656
1.44	2.3634	2.2132	2.1292	2.0752	3.84	8.1605	7.8137	7.6201	7.4957
1.48	2.4175	2.2653	2.1802	2.1255	3.88	8.3007	7.9493	7.7532	7.6273
1.52	2.4730	2.3188	2.2325	2.1771	3.92	8.4424	8.0864	7.8877	7.7602
1.56	2.5300	2.3737	2.2863	2.2301	3.96	8.5854	8.2248	8.0236	7.8944
1.60	2.5884	2.4300	2.3414	2.2845	4.00	8.7300	8.3646	8.1608	8.0300
1.64	2.6483	2.4877	2.3980	2.3402	4.04	8.8759	8.5058	8.2994	8.1669
1.68	2.7096	2.5469	2.4559	2.3974	4.08	9.0232	8.6484	8.4394	8.3051
1.72	2.7724	2.6074	2.5152	2.4558	4.12	9.1719	8.7923	8.5807	8.4447
1.76	2.8367	2.6694	2.5758	2.5157	4.16	9.3221	8.9377	8.7233	8.5857
1.80	2.9024	2.7328	2.6379	2.5769	4.20	9.4737	9.0844	8.8673	8.7280
1.84	2.9695	2.7975	2.7013	2.6394	4.24	9.6267	9.2325	9.0127	8.8716
1.88	3.0382	2.8637	2.7661	2.7034	4.28	9.7811	9.3819	9.1594	9.0166
1.92	3.1082	2.9313	2.8323	2.7686	4.32	9.9370	9.5328	9.3075	9.1629
1.96	3.1797	3.0003	2.8999	2.8353	4.36	10.0943	9.6850	9.4569	9.3106
2.00	3.2527	3.0706	2.9688	2.9033	4.40	10.2530	9.8386	9.6077	9.4596
2.04	3.3271	3.1424	3.0391	2.9727	4.44	10.4130	9.9936	9.7599	9.6099
2.08	3.4029	3.2156	3.1108	3.0434	4.48	10.5746	10.1499	9.9134	9.7616
2.12	3.4802	3.2902	3.1839	3.1155	4.52	10.7375	10.3077	10.0682	9.9147
2.16	3.5589	3.3662	3.2583	3.1889	4.56	10.9019	10.4668	10.2245	10.0690
2.20	3.6391	3.4436	3.3341	3.2638	4.60	11.0677	10.6273	10.3820	10.2247
2.24	3.7207	3.5223	3.4113	3.3399	4.64	11.2349	10.7891	10.5410	10.3818
2.28	3.8038	3.6025	3.4899	3.4174	4.68	11.4035	10.9524	10.7013	10.5402
2.32	3.8883	3.6841	3.5698	3.4963	4.72	11.5735	11.1170	10.8629	10.7000
2.36	3.9742	3.7671	3.6511	3.5766	4.76	11.7450	11.2830	11.0259	10.8611
2.40	4.0616	3.8514	3.7338	3.6582	4.80	11.9178	11.4504	11.1903	11.0235
2.44	4.1504	3.9372	3.8179	3.7411	4.84	12.0921	11.6192	11.3560	11.1873
2.48	4.2407	4.0243	3.9033	3.8254	4.88	12.2678	11.7895	11.5230	11.3524
2.52	4.3324	4.1129	3.9901	3.9111	4.92	12.4449	11.9608	11.6914	11.5188
2.56	4.4255	4.2028	4.0782	3.9981	4.96	12.6234	12.1337	11.8612	11.6866
2.60	4.5201	4.2942	4.1678	4.0865	5.00	12.8034	12.3079	12.0324	11.8558
2.64	4.6161	4.3869	4.2587	4.1762	5.04	12.9848	12.4836	12.2048	12.0263
2.68	4.7135	4.4810	4.3509	4.2673	5.08	13.1676	12.6606	12.3787	12.1981
2.72	4.8124	4.5765	4.4446	4.3597	5.12	13.3518	12.8390	12.5539	12.3712
2.76	4.9127	4.6734	4.5396	4.4535	5.16	13.5374	13.0187	12.7304	12.5457
2.80	5.0144	4.7717	4.6359	4.5486	5.20	13.7245	13.1999	12.9083	12.7216
2.84	5.1175	4.8714	4.7337	4.6451	5.24	13.9129	13.3824	13.0876	12.8988
2.88	5.2221	4.9724	4.8328	4.7429	5.28	14.1027	13.5663	13.2682	13.0773
2.92	5.3282	5.0749	4.9332	4.8421	5.32	14.2940	13.7516	13.4502	13.2572
2.96	5.4356	5.1787	5.0351	4.9427	5.36	14.4867	13.9382	13.6335	13.4384
3.00	5.5445	5.2840	5.1383	5.0446	5.40	14.6809	14.1262	13.8182	13.6209
3.04	5.6548	5.3906	5.2428	5.1478	5.44	14.8763	14.3156	14.0042	13.8048
3.08	5.7665	5.4986	5.3488	5.2524	5.48	15.0733	14.5064	14.1916	13.9901
3.12	5.8797	5.6080	5.4560	5.3583	5.52	15.2717	14.6986	14.3803	14.1766
3.16	5.9943	5.7188	5.5647	5.4656	5.56	15.4714	14.8921	14.5704	14.3646
3.20	6.1103	5.8309	5.6747	5.5743	5.60	15.6727	15.0870	14.7619	14.5538
3.24	6.2278	5.9445	5.7861	5.6843	5.64	15.8752	15.2833	14.9547	14.7444
3.28	6.3466	6.0594	5.8988	5.7956	5.68	16.0792	15.4809	15.1488	14.9364
3.32	6.4670	6.1757	6.0129	5.9083	5.72	16.2847	15.6800	15.3443	15.1296
3.36	6.5887	6.2934	6.1284	6.0223	5.76	16.4915	15.8804	15.5412	15.3242

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TABLE VII - VARIATION OF SHAPE PARAMETER H WITH MACH NUMBER M AND VELOCITY-PROFILE PARAMETER N - Concluded

$$\left[H = \frac{\delta^*}{\theta}\right]$$

(b) Supersonic flow - Concluded.

Mach number M	Velocity-profile parameter, N				Mach number M	Velocity-profile parameter, N			
	5	7	9	11		5	7	9	11
5.80	16.6998	16.0822	15.7394	15.5202	8.20	31.7843	30.7051	30.1091	29.7299
5.84	16.9094	16.2853	15.9390	15.7175	8.24	32.0788	30.9908	30.3898	30.0077
5.88	17.1204	16.4898	16.1399	15.9162	8.28	32.3742	31.2778	30.6719	30.2866
5.92	17.3331	16.6957	16.3422	16.1161	8.32	32.6721	31.5661	30.9554	30.5670
5.96	17.5469	16.9030	16.5458	16.3175	8.36	32.9707	31.8560	31.2402	30.8488
6.00	17.7624	17.1117	16.7508	16.5201	8.40	33.2712	32.1471	31.5265	31.1318
6.04	17.9791	17.3217	16.9571	16.7241	8.44	33.5727	32.4396	31.8139	31.4162
6.08	18.1971	17.5331	17.1648	16.9294	8.48	33.8751	32.7336	32.1029	31.7020
6.12	18.4168	17.7459	17.3739	17.1361	8.52	34.1800	33.0288	32.3931	31.9889
6.16	18.6378	17.9601	17.5843	17.3441	8.56	34.4857	33.3254	32.6847	32.2774
6.20	18.8603	18.1755	17.7960	17.5535	8.60	34.7932	33.6234	32.9776	32.5671
6.24	19.0840	18.3925	18.0091	17.7642	8.64	35.1020	33.9230	33.2719	32.8583
6.28	19.3091	18.6107	18.2236	17.9763	8.68	35.4113	34.2236	33.5676	33.1506
6.32	19.5359	18.8304	18.4394	18.1897	8.72	35.7235	34.5258	33.8646	33.4445
6.36	19.7639	19.0514	18.6565	18.4043	8.76	36.0363	34.8293	34.1630	33.7395
6.40	19.9936	19.2739	18.8751	18.6204	8.80	36.3506	35.1343	34.4627	34.0361
6.44	20.2243	19.4976	19.0949	18.8378	8.84	36.6664	35.4406	34.7638	34.3339
6.48	20.4565	19.7228	19.3162	19.0565	8.88	36.9828	35.7481	35.0662	34.6330
6.52	20.6904	19.9493	19.5387	19.2766	8.92	37.3021	36.0573	35.3700	34.9335
6.56	20.9255	20.1772	19.7627	19.4980	8.96	37.6218	36.3677	35.6751	35.2353
6.60	21.1622	20.4065	19.9880	19.7208	9.00	37.9438	36.6794	35.9817	35.5384
6.64	21.4000	20.6371	20.2146	19.9449	9.04	38.2662	36.9926	36.2894	35.8429
6.68	21.6393	20.8692	20.4426	20.1704	9.08	38.5897	37.3072	36.5986	36.1488
6.72	21.8802	21.1026	20.6720	20.3971	9.12	38.9157	37.6230	36.9091	36.4559
6.76	22.1224	21.3374	20.9027	20.6252	9.16	39.2421	37.9402	37.2211	36.7646
6.80	22.3662	21.5736	21.1347	20.8548	9.20	39.5716	38.2590	37.5344	37.0744
6.84	22.6111	21.8111	21.3681	21.0855	9.24	39.9010	38.5789	37.8490	37.3855
6.88	22.8575	22.0500	21.6028	21.3177	9.28	40.2313	38.9003	38.1649	37.6981
6.92	23.1056	22.2903	21.8390	21.5512	9.32	40.5656	39.2232	38.4823	38.0120
6.96	23.3548	22.5319	22.0765	21.7860	9.36	40.8993	39.5474	38.8008	38.3272
7.00	23.6056	22.7749	22.3153	22.0221	9.40	41.2352	39.8730	39.1209	38.6437
7.04	23.8576	23.0193	22.5554	22.2596	9.44	41.5722	40.1998	39.4422	38.9616
7.08	24.1109	23.2651	22.7970	22.4984	9.48	41.9098	40.5280	39.7650	39.2810
7.12	24.3660	23.5122	23.0398	22.7386	9.52	42.2506	40.8578	40.0891	39.6014
7.16	24.6223	23.7608	23.2840	22.9801	9.56	42.5912	41.1887	40.4145	39.9234
7.20	24.8803	24.0107	23.5296	23.2230	9.60	42.9342	41.5212	40.7414	40.2466
7.24	25.1393	24.2619	23.7766	23.4672	9.64	43.2781	41.8552	41.0695	40.5713
7.28	25.3996	24.5146	24.0248	23.7127	9.68	43.6224	42.1902	41.3991	40.8973
7.32	25.6619	24.7687	24.2745	23.9596	9.72	43.9703	42.5267	41.7299	41.2244
7.36	25.9251	25.0240	24.5255	24.2078	9.76	44.3183	42.8646	42.0621	41.5532
7.40	26.1903	25.2808	24.7778	24.4574	9.80	44.6682	43.2040	42.3956	41.8831
7.44	26.4564	25.5390	25.0316	24.7083	9.84	45.0198	43.5448	42.7306	42.2144
7.48	26.7238	25.7985	25.2866	24.9606	9.88	45.3714	43.8867	43.0669	42.5471
7.52	26.9935	26.0594	25.5430	25.2142	9.92	45.7264	44.2302	43.4045	42.8809
7.56	27.2639	26.3217	25.8008	25.4691	9.96	46.0818	44.5750	43.7435	43.2163
7.60	27.5359	26.5853	26.0600	25.7253	10.00	46.4388	44.9212	44.0837	43.5531
7.64	27.8094	26.8503	26.3203	25.9829					
7.68	28.0836	27.1167	26.5822	26.2418					
7.72	28.3602	27.3846	26.8453	26.5021					
7.76	28.6376	27.6536	27.1099	26.7637					
7.80	28.9167	27.9243	27.3758	27.0267					
7.84	29.1971	28.1962	27.6430	27.2910					
7.88	29.4785	28.4693	27.9116	27.5566					
7.92	29.7621	28.7440	28.1816	27.8235					
7.96	30.0467	29.0201	28.4528	28.0919					
8.00	30.3328	29.2975	28.7255	28.3616					
8.04	30.6203	29.5762	28.9995	28.6326					
8.08	30.9087	29.8564	29.2748	28.9049					
8.12	31.1995	30.1379	29.5515	29.1786					
8.16	31.4909	30.4208	29.8297	29.4535					

NACA

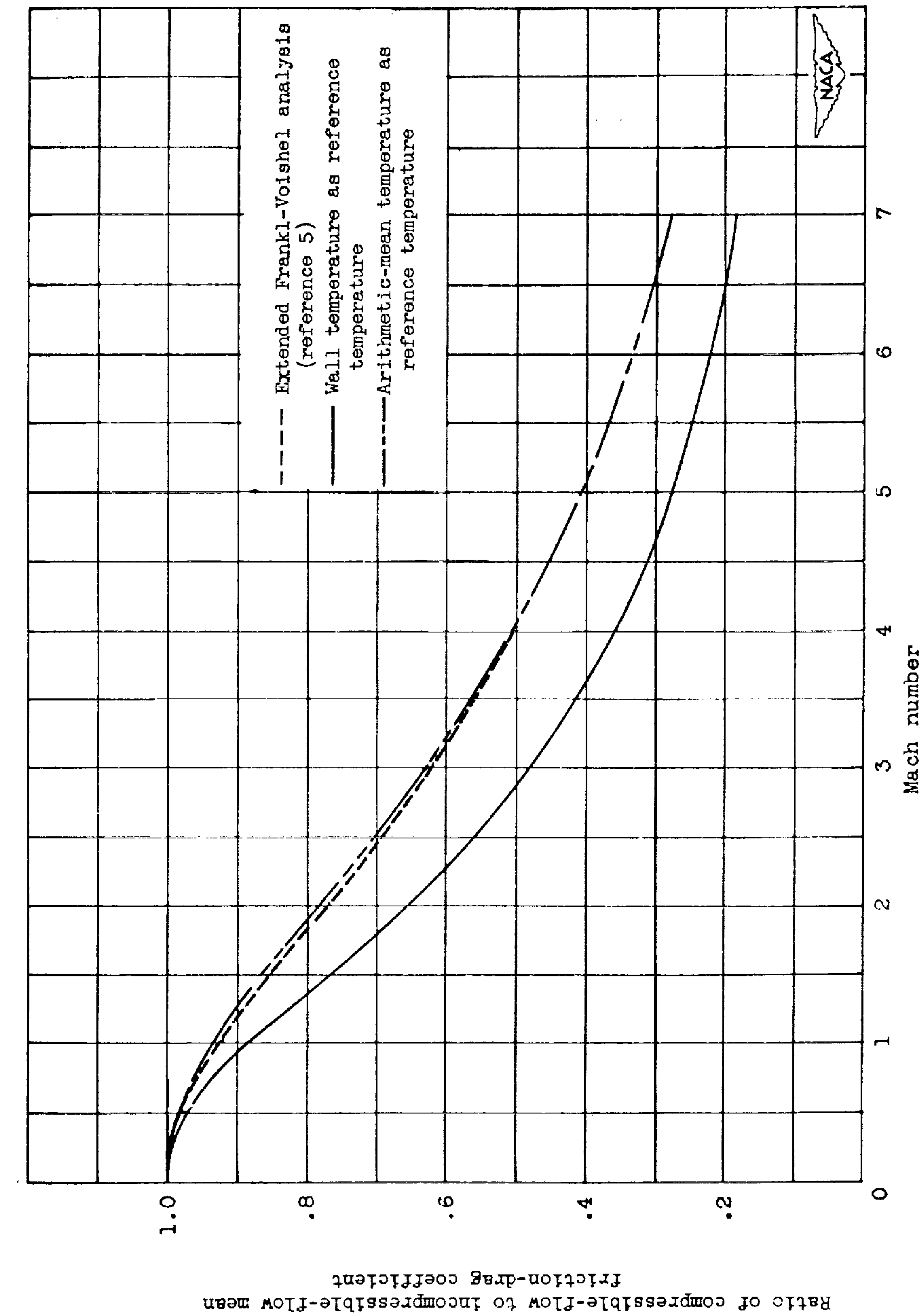
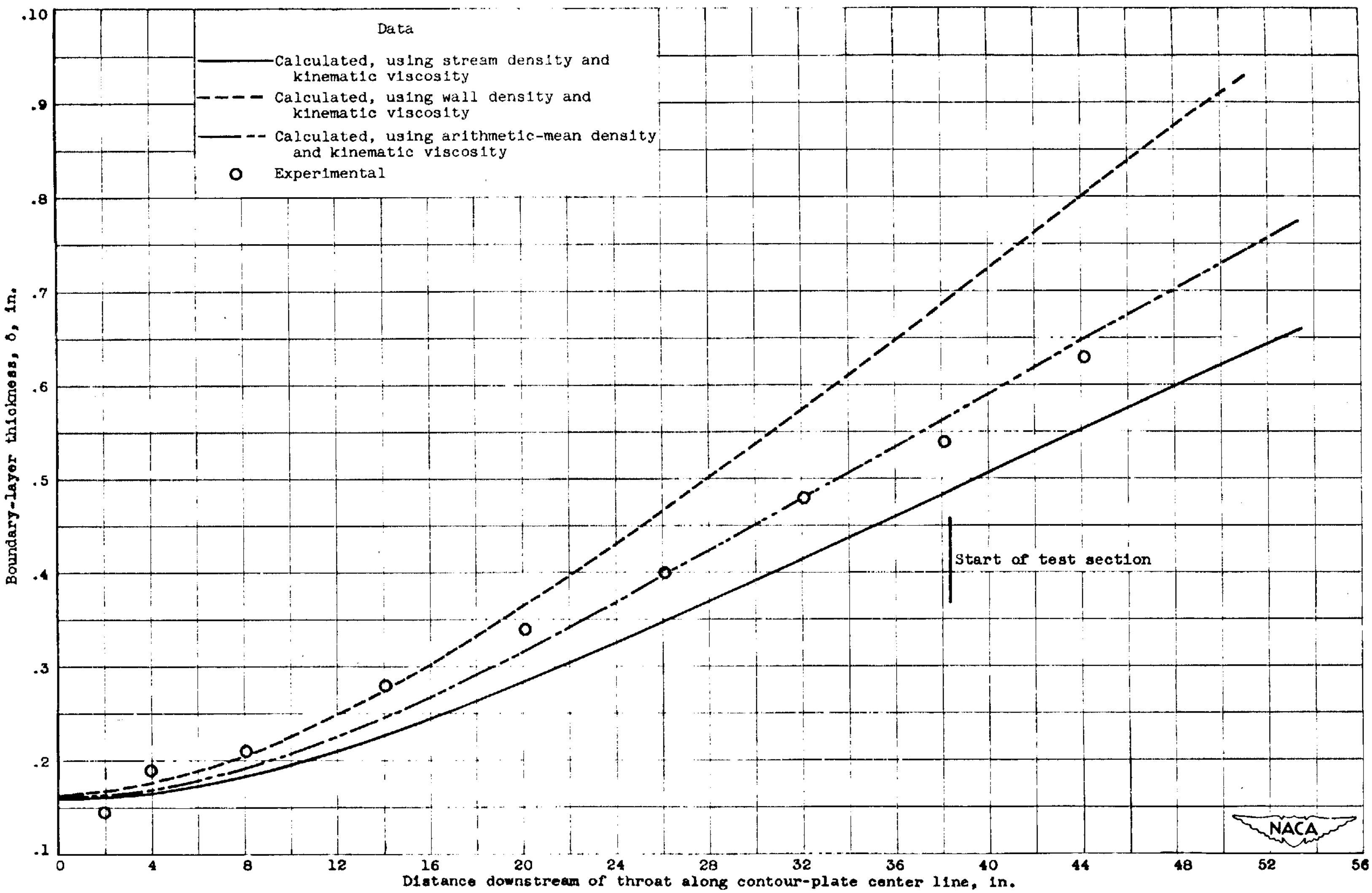
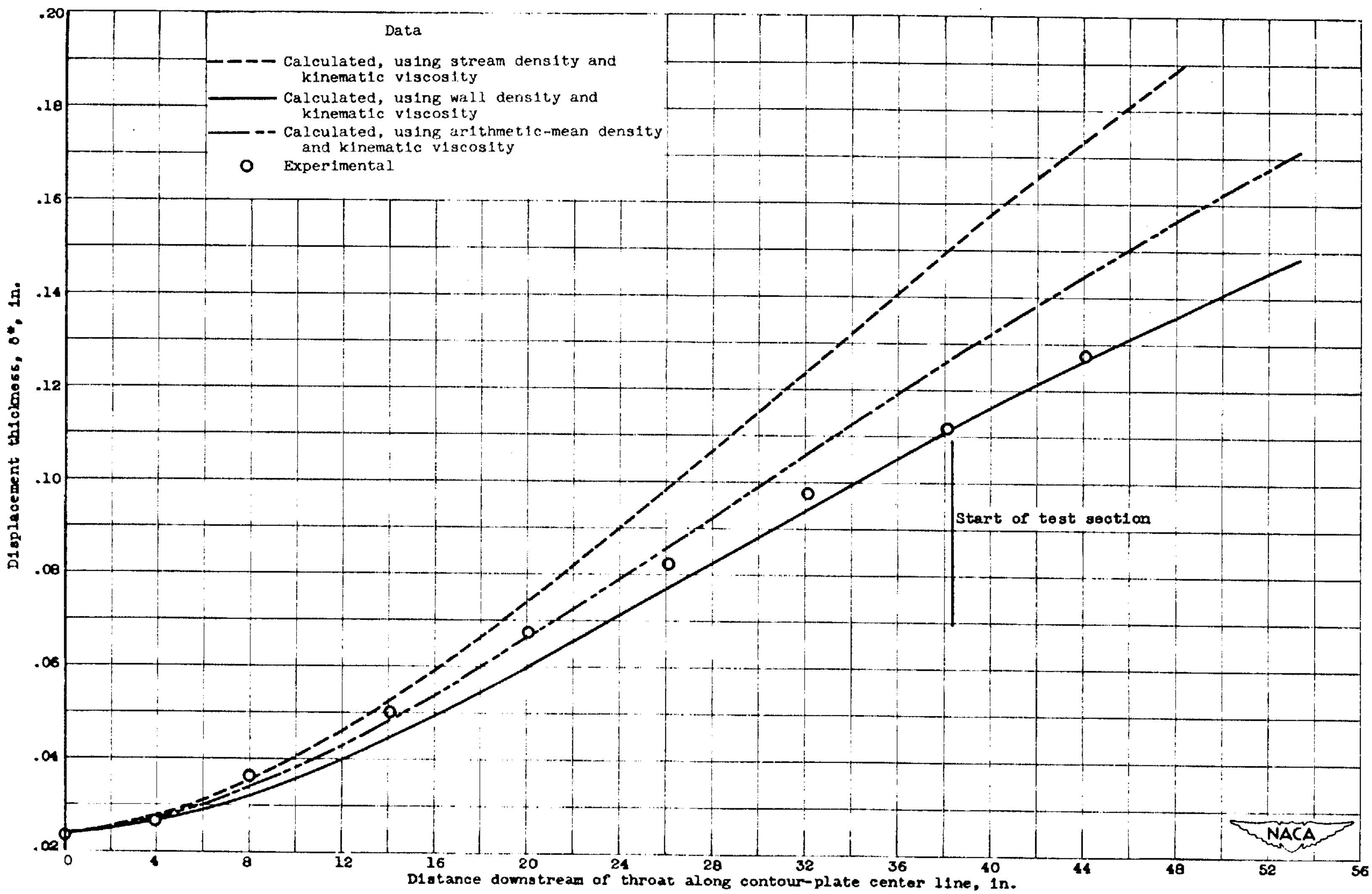


Figure 1. - Effect of Mach number upon flat-plate mean friction-drag coefficient at constant free-stream Reynolds number.



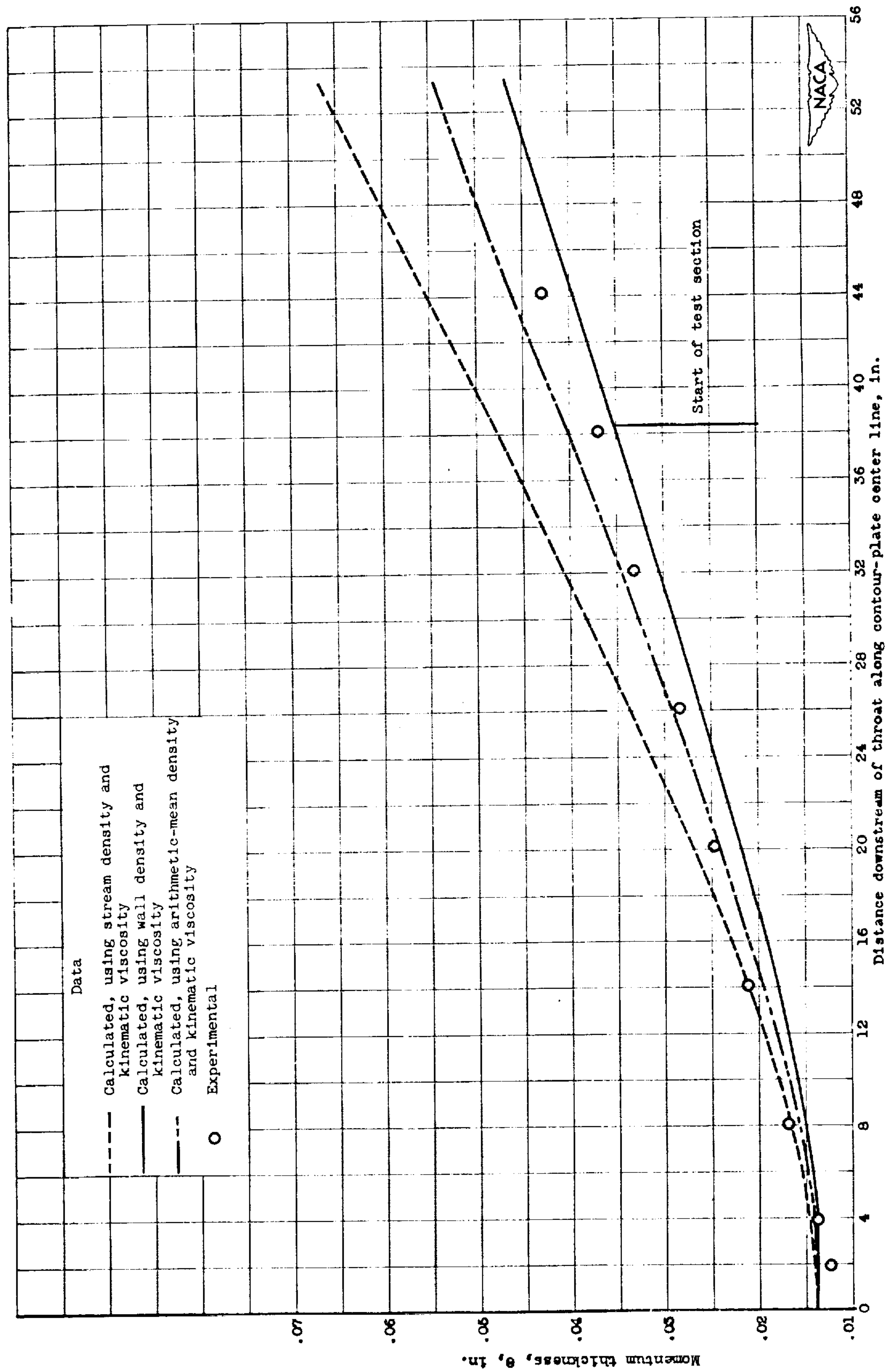
(a) Boundary-layer thickness.

Figure 2. - Comparison of calculated and experimental boundary-layer development along contour-plate center line of 3.84- by 10-inch Mach number 2.08 supersonic tunnel.



(b) Displacement thickness.

Figure 2. - Continued. Comparison of calculated and experimental boundary-layer development along contour-plate center line of 3.84- by 10-inch Mach number 2.08 supersonic tunnel.



(c) Momentum thickness.

Figure 2. - Concluded. Comparison of calculated and experimental boundary-layer development along contour-plate center line of 3.84- by 10-inch Mach number 2.08 supersonic tunnel.